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Permethrin in New Brunswick Salmon Nursery Streams.

Edited by P.D. Kingsbury

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CAPTIONS FOR COVER PHOTO, CLOCKWISE FROM TOP:

1. *Cessna Ag truck aircraft applying permethrin.*
2. *Electoshocking in Young's Brook.*
3. *Juvenile Atlantic salmon from Young's Brook.*
4. *Placing crayfish in holding cages in Young's Brook.*

PERMETHRIN IN NEW BRUNSWICK
SALMON NURSERY STREAMS

Edited by

P. D. Kingsbury

Forest Pest Management Institute
Sault Ste. Marie, Ontario

Report FPM-X-52

Canadian Forestry Service
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August 1983

ERRATUM

The French title of this report should read "Arrosages de perméthrine dans les frayères à saumon du Nouveau-Brunswick" instead of "Perméthrine dans les rivières ensemencées de saumons du Nouveau-Brunswick." (Copyright page).

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PERMETHRIN IN NEW BRUNSWICK SALMON NURSERY STREAMS

Forest Pest Management Institute Report FPM-X-52

ABSTRACT

Permethrin was applied at 17.5 g AI/ha by aircraft to two 600-ha blocks located on tributaries of the Nashwaak River, N.B., in June 1980. One block received a single application and the other was treated twice with a 4-day interval between sprays. Permethrin residues in stream water did not exceed 0.96 μg/L and approached or fell below detectable levels (0.02 μg/L) within 24 hours. Residual permethrin in fish tissue peaked at 0.095 μg/g and in some instances persisted above detectable levels (0.005 μg/g) for more than 28 days but less than 70 days postspray. No detectable levels of permethrin were measured in crayfish exposed to the applications in holding cages. Accumulation of residual permethrin in stream sediment was minimal (<0.025 μg/g), but was considerably higher and more stable in forest litter with peak levels as high as 0.750 μg/g and persistence to the end of the 68-day postspray sampling period at levels up to 0.037 μg/g.

The permethrin applications to both the single and double blocks caused massive disturbances of aquatic invertebrates resulting in catastrophic drift for 3-12 hours. Subsequent reductions in benthos density were documented in, and 1.4 km below, the double application block, but were less apparent in the single block. Recovery of benthos numbers was essentially complete by September 1980. Feeding activity of resident salmonids in the treatment blocks corresponded to the availability of food items. Following initial postspray feeding on pesticide-affected invertebrates, the diets of brook trout and juvenile Atlantic salmon demonstrated a declining selection of aquatic insects at least partly attributable to the measured reduction in benthos. One-year postspray sampling of benthos and fish stomach contents in the treated areas demonstrated a variety and abundance of aquatic invertebrates and fish food organisms comparable to prespray samples.

No pesticide-related mortality of resident fish, caged salmon parr, or salmon sac-fry held in upwelling boxes was observed during or after the permethrin applications, but inconclusive evidence suggested delayed toxic or sublethal effects on caged crayfish. Results from fish population estimates and observations indicated a postspray emigration of some brook trout and juvenile Atlantic salmon from the treated areas, probably in response to a depleted food resource. The growth rates of 1- and 2-year-old salmon parr within the double application block were lower than at other sites between May and July, but higher between July and September to the extent that there were no significant treatment-induced differences in the size of salmon parr at treated and control sites by the end of the summer.

The permethrin applications to both treatment blocks resulted in a measurable knockdown of nontarget arboreal and flying arthropods from pin cherry blossom and balsam fir foliage.

RÉSUMÉ

En juin 1980, deux blocs de 600 ha donnant sur des tributaires de la rivière Nashwaak, au Nouveau-Brunswick, ont été traités par pulvérisation aérienne de perméthrine à la dose de 17,5 g (I.A.)/ha. Un bloc a été traité en un arrosage, l'autre, en deux arrosages à quatre jours d'intervalle. La concentration des résidus dans les cours d'eau n'a pas dépassé 0,96 µg/L et est retombée au-dessous ou près du niveau de détection (0,02 µg/L) en moins de 24 heures. Dans les tissus des poissons, la concentration a atteint 0,095 µg/g et, dans certains cas, est demeurée supérieure au niveau de détection (0,005 µg/g) pendant plus de 28 jours, mais moins de 70, après l'arrosage. Des écrevisses exposées en cages ne présentaient pas de concentrations mesurables dans leurs tissus. L'accumulation des résidus a été minime dans les sédiments des cours d'eau (≤0,025 µg/g), mais considérablement plus élevée et plus stable dans la litière forestière où les concentrations ont atteint 0,750 µg/g et pouvaient encore s'élever à 0,037 µg/g à la fin de la période d'échantillonage de 68 jours après le traitement.

Dans les deux blocs, les arrosages ont grandement dérangé les invertébrés aquatiques dont on a observé une dispersion catastrophique pendant 3 à 12 heures. Une baisse de la densité du benthos a par la suite été enregistrée dans le bloc arrosé deux fois et à 1,4 km en aval. La baisse a été moins nette dans le bloc arrosé une seule fois. La densité du benthos était essentiellement rétablie en septembre 1980. L'activité alimentaire des salmonidés résidant dans les blocs traités a correspondu à l'abondance des ressources alimentaires. Après l'arrosage, les ombles de fontaine et les saumons de l'Atlantique juvéniles se sont d'abord nourris d'invertébrés touchés par le pesticide puis ont affiché une moins grande sélectivité envers les insectes aquatiques, ce qui serait au moins partiellement attribuable à la baisse observée du benthos. Un an après les arrosages, un échantillonnage du benthos et du contenu stomacal de poissons dans les zones traitées a indiqué que la variété et l'abondance des invertébrés aquatiques et des organismes servant de nourriture aux poissons étaient comparables à la situation avant les arrosages.

Aucune mortalité attribuable au pesticide n'a été observée pendant ou après les arrosages chez les poissons résidents, les tacons de saumon en cages et les alevins vésiculés gardés dans des caisses à courant ascendant; mais d'après des données non concluantes, il y aurait des effets toxiques ou sublétaux à manifestation retardée chez les écrevisses en cages. Les estimations et observations des populations de poissons indiquent une émigration après les arrosages d'une partie des ombles de fontaine et des saumons de l'Atlantique juvéniles des zones traitées, qui est probablement attribuable à la diminution des ressources alimentaires. Les taux de croissance des tacons de saumon d'un et de deux ans dans le bloc arrosé deux fois ont été plus faibles qu'à d'autres endroits entre mai et juillet, mais ils ont été plus élevés entre juillet et septembre, au point qu'à la fin de l'été il n'y avait pas de diffférence significative de taille entre les tacons des emplacements traités et ceux des emplacements témoins.

Dans les deux blocs traités, on a observé un effet de choc mesurable chez les arthropodes arboricoles et volants non cibles se trouvant sur les fleurs du cerisier de Pennsylvanie et le feuillage du sapin baumier.

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Any impact study of this magnitude involves the efforts and cooperation of numerous persons from the collaborating industries and agencies, and this program was no exception. The authors wish to express their appreciation to the following:

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I. INTRODUCTION

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Forest Pest Management Institute

The development and use of chemical pesticides over the past few decades has dramatically altered forestry practices by providing tools for protecting and managing timber resources to increase forest productivity and the benefits stemming from multiple-use of forests. At the same time, there has been an increasing awareness and concern over both documented and potential effects of these chemicals on forest environments and human health. Canada's forest resources and forest-based industries are one of her greatest social and economic assets. However, these forests are endangered by formidable forest insect pest problems. The Canadian Forestry Service carries out an extensive research and development program, centered largely at the Forest Pest Management Institute (FPMI) in Sault Ste. Marie, to develop and improve chemical, biological, and integrated pest control agents and strategies that will protect forest resources while maintaining the integrity of forest and human environments.

An important development in the field of insect pest control was made in 1973 when the first photostable synthetic pyrethroids were described (Elliot et al. 1973a, b). These compounds combined the high activity against insects and low mammalian toxicity of the natural pyrethrins with a greatly increased stability under environmental conditions. Once the structural requirements for photostable pyrethroids were established, a great number of new compounds with similar biological properties were synthesized in the mid-70s. Although field evaluations of these compounds are barely completed, it is apparent that many of them are outstandingly effective against various insect pests and, unless unforeseen toxicological hazards or other disadvantages are discovered, they will become increasingly used tools in insect control progams (Elliot et al. 1978).

Numerous synthetic pyrethroid insecticides were submitted to the Chemical Control Research Institute (now the Forest Pest Management Institute) early in their development, for screening against Canadian forest insect pest species, of which the most prominent is the spruce budworm, *Choristoneura fumiferana* (Clem.). When their high level of activity against lepidopterous pest species became apparent (Nigam 1975; Robertson et al. 1976), the decision was made to select a single compound representative of this new group to be fully evaluated for its potential use as an environmentally acceptable spruce budworm control agent. It was felt that this would provide the necessary data for comparing the potential of synthetic pyrethroids to organophosphate and carbamate insecticides currently in use or under development, and also set a baseline against which to evaluate other candidate synthetic pyrethroid materials. The compound selected was permethrin [NRDC 143; 3-phenoxybenzyl (±)-cis,trans-3-(2,2-dichlorovynyl) 2,2-dimethylcylopropranecarboxylate)], the first of the new synthetic pyrethroids synthesized and chemically the simplest of the NRDC series of compounds (NRDC 143 to NRDC 161), whose discovery precipitated activities in the development of numerous other photostable synthetic pyrethroids (Ruscoe 1977). Permethrin has been developed for use against numerous agricultural, orchard, and greenhouse pests and is currently registered in Canada for use on a wide range of crops to control chewing, sucking, and leaf-mining insects and as a surface spray for fly control in farm buildings (DeBoo 1980). Recommended application rates range from 35-210 g AI/ha.

Simulated aerial spray trials on individual trees (Hopewell 1975, 1977), experimental ground applications by mistblower (DeBoo 1980a), and small-block, aerial application trials (DeBoo 1980b) were carried out by the Forest Pest Management Institute between 1975 and 1977. These trials confirmed the effectiveness of permethrin as a spruce budworm control agent. Mistblower trials with dosage rates between 7 and 70 g AI/ha led to the conclusion that generally not more than 35 g AI/ha would be required for effective control and foliage protection from serious spruce budworm infestations (DeBoo 1980a). Aerial application trials suggested that a single application of permethrin at 17.5 g AI/ha was similar in effectiveness to a conventional fenitrothion treatment emitted at 210-280 g AI/ha, with two applications of permethrin at 17.5 g AI/ha several days apart considered to be the most practical dosage for semi-operational evaluation (DeBoo 1980b).

Concurrent with field efficacy trials, intensive field environmental impact trials were initiated in 1976, concentrating on assessing the effects of permethrin on aquatic systems because of the well-known high toxicity of pyrethrins and synthetic pyrethroids to aquatic organisms. The types of systems studied by FPMI between 1976 and 1979 and the dosages of permethrin applied to them are summarized in Table 1. Initial studies were carried out at relatively high application rates to assess potential lethal effects on fish. These studies were carried out in small lakes and streams with large populations of fish representing various families (Kingsbury 1976a, b). Subsequent studies concentrated on determining the effects of a range of dosages between 9 and 70 g AI/ha on trout and aquatic invertebrates in small forest streams (Kingsbury and Kreutzweiser 1980b) and replicated studies on the effects of permethrin applied to trout streams and forest ponds at 2 x 17.5 g AI/ha, the dosage considered to be the most practical for operational evaluation (Kingsbury and Kreutzweiser 1979). Terrestrial impact studies at this dosage rate were initiated at this point to evaluate effects on song birds, small mammals, and nontarget insects resident in various forest types, as well as introduced colonies of domestic honeybees (Kingsbury and McLeod 1979). In 1979, aquatic and terrestrial impact studies were conducted in a 640-ha, semi-operational block covering the headwater portion of a stream system draining a black spruce bog (Kingsbury and Kreutzweiser 1980a). In both 1978 and 1979, biological studies were accompanied by intensive sampling to determine the levels and fate of permethrin residues in various forest substrates, with the analytical work carried out by chemists of Chipman Inc.

Table 1. Field studies carried out by the Forest Pest Management Institute from 1976 to 1979 on the environmental impact of permethrin

Year of application	Location of studies	Dosage (active ingredient)	Systems studied	Reference
1976	Lac Tassel, Que.	140 g/ha	Small lake with smallmouth bass population	Kingsbury 1976a, b
	Young's Creek, PFES*, Ont.	70 g/ha	Sand-bottomed stream with minnow population	
	Thomas Lake, PFES, Ont.	35 g/ha	Small lake with coarse fish populations	
1977	Ruisseau Landry, Que.	70 g/ha	Trout stream	Kingsbury and Kreutzweiser 1980b
	Ruisseau du Petit Capucin, Que.	35 g/ha	Trout stream	
1978	Ruisseau Robichaud, Que.	17.5 g/ha	Trout stream	
	England Creek, Que.	8.8 g/ha	Trout stream	
	Little Baker Brook, Que.	2 x 17.5 g/ha	Trout stream	Kingsbury and Kreutzweiser 1979
	North Baker Brook, Que.	2 x 17.5 g/ha	Trout stream	
	Riviere de la Pointe au Sable, Que.	2 x 17.5 g/ha	Trout stream	
	Larose Forest, Ont.	2 x 17.5 g/ha	Forest ponds with minnow populations	
	Larose Forest, Ont.	2 x 17.5 g/ha	Song birds, honeybees, and small mammals in various forest types	Kingsbury and McLeod 1979
1979	Shaft Creek, Longlac, Ont.	17.5 g/ha	Headwater stream system in black spruce bog, resident terrestrial invertebrates, and small mammals	Kingsbury and Kreutzweiser 1980a

* PFES – Petawawa Forest Experiment Station

Briefly, the following conclusions resulted from environmental impact studies conducted by FPMI prior to 1980 relating to the effects of permethrin applied as a spruce budworm control agent.

(1) Fish mortality due to acute toxic effects is unlikely to occur when permethrin is applied to aquatic systems in forested areas at dosage rates suitable for effective spruce budworm control.

(2) Aerial applications of permethrin cause substantial adverse effects on aquatic invertebrate populations. These effects decrease with lower dosages, but are still readily apparent among the most sensitive groups (Ephemeroptera, Trichoptera, and to a lesser extent Plecoptera) at application rates as low as 9 g AI/ha.

(3) Effects of single applications of permethrin, measured in terms of population reductions at the order level, persist beyond the year of treatment with application rates of 70 g AI/ha or greater. At lower application rates, virtually complete recovery of numbers occurs within a year of treatment.

(4) Double applications of permethrin at 17.5 g AI/ha cause substantial reductions to bottom fauna populations with the second application apparently very significant in reducing populations to a point at which recovery of numbers is considerably slower than after the impact caused by a single application at this dosage.

(5) Aquatic invertebrates can be affected by toxic levels of permethrin considerable distances downstream and a number of hours after applications to upstream areas at dosages as low as 17.5 g AI/ha.

(6) Single applications of permethrin at 35 and 70 g AI/ha to trout streams caused large shifts in the diets of native brook trout populations from aquatic insect to terrestrial food sources after initial gorging on affected aquatic insects. Applications of lower dosages of permethrin caused only small deviations in trout diets from those in the untreated control streams. The diets of native slimy sculpin populations in streams treated with double applications of 17.5 g AI/ha shifted from a diet of various aquatic insects to mostly midge larvae for several months before returning to a varied diet late in the year of application.

(7) Peak permethrin residues measured after applications of 17.5 g AI/ha have never exceeded 2.5 μg/L in streams, but residues as high as 147.0 μg/L have been found in pond water shortly after application. Residues in water fall below detectable limits very rapidly. Various results have been obtained concerning permethrin residues in pond and stream sediments and fish tissue, but residues exceeding 0.04 μg/g in sediments or 0.12 μg/g in fish have not been found after 17.5 g AI/ha applications.

(8) No evidence has been found to suggest that permethrin applications affect breeding songbirds or small mammals.

(9) Aerial permethrin applications cause moderate to heavy knockdown of terrestrial arthropods from trees and shrubs for up to 2 days after application, but have only been found to have slight effects on honeybee colonies or activity of ground dwelling invertebrates.

(10) Permethrin residues measured following applications of 17.5 g AI/ha were higher for deciduous foliage (peak levels for various species between 0.78 and 1.55 µg/g) than for coniferous foliage (peak levels for various species between 0.24 and 0.32 µg/g). Residues gradually declined to approach detection limits (0.01 µg/g) within 2 months in both coniferous and deciduous foliage. Peak permethrin residues measured in forest soil and litter were lower than those found in foliage (0.07-0.12 µg/g in soil, 0.21 µg/g in litter) but appeared to be relatively stable over a 2-month period.

Little other information on environmental effects of permethrin relevant to Canadian forest situations is currently available in the scientific literature. Some laboratory toxicity studies have been carried out on important Canadian maritime organisms at the Department of Fisheries and Oceans Biological Station, St. Andrews, N.B. (Zitko et al. 1977, 1979; McLeese et al. 1980), in response to concerns over potential use of this material against spruce budworm in that region. Other laboratory toxicity studies on various aquatic organisms have been carried out to study potential effects of permethrin used as a mosquito larvicide (Mulla et al. 1978a, b; Coats and O'Donnell-Jeffrey 1979), cotton insecticide (Jolly et al. 1978), or blackfly larvicide in vector control programs (Muirhead-Thomson 1977, 1978). Toxicity values reported in these studies have been summarized in Table 2, and show both the high toxicity of permethrin to fish and its even greater toxicity to crustaceans and aquatic insects. However, it is difficult to relate these toxicity values to field situations as most of them were generated under static conditions where the test organisms were exposed to relatively constant permethrin concentrations over the entire duration of the bioassay. Test conditions more closely approximating field conditions were used by Muirhead-Thomson (1978), who exposed test organisms to permethrin for 1 hour in a flow-through test vessel, followed by a 24-hour holding period in continuous-flowing clean water, at the end of which mortality was assessed. When toxicity to rainbow trout was assessed under these conditions, lethal effects were not apparent until trout were exposed to 100 µg/L of permethrin (Muirhead-Thomson 1978), a value considerably higher than LC_{50} values arrived at by Mulla et al. (1978a) under static bioassay conditions.

Kumaraguru and Beamish (1981) have demonstrated the large influences that test temperature and test organism body weight have on the tolerance of rainbow trout to permethrin. They showed that the 96 h LC_{50} of permethrin to 1 g rainbow trout increased by an order of magnitude between 5 and 20°C, with the greatest decrease in toxicity between 10 and 20°C. The influence of body weight was even greater, with the 96 h LC_{50} at 15°C increasing by two orders of magnitude with an increase in the body weight of the fish tested from 1 to 200 g, the most pronounced change occurring between 1 and 50 g.

Table 2. Published values for toxicity of permethrin to aquatic organisms

Species tested	Formulation tested	Toxicity reported	Value	Reference
Fish				
Atlantic salmon *(Salmo salar)*	Technical material (92% AI)	lethal threshold	8.8 μg/L	Zitko et al. 1977
	Technical material (92% AI)	lethal threshold	5.0 μg/L	McLeese et al. 1980
	Technical material (92% AI)	96 h LC_{50}	12.0 μg/L	McLeese et al. 1980
Rainbow trout *(Salmo gairdneri)*	Technical material (92-96% AI)	24 h LC_{50}	135.0 μg/L	Coats and O'Donnell-Jeffery
	Emulsifiable concentrate (25% AI)	24 h LC_{50}	61.0 μg/L	Coats and O'Donnell-Jeffery
	Emulsifiable concentrate	24 h LC_{50}	8.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	24 h LC_{90}	17.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	48 h LC_{50}	6.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	48 h LC_{90}	10.0 μg/L	Mulla et al. 1978a
Mosquito fish *(Gambusia affinis)*	Emulsifiable concentrate	24 h LC_{50}	100.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	24 h LC_{90}	250.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	48 h LC_{50}	97.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	48 h LC_{90}	250.0 μg/L	Mulla et al. 1978a
	Emulsifiable concentrate	96 h LC_{50}	15.0 μg/L	Jolly et al. 1978
Channel catfish *(Ictalurus punctatus)*	Emulsifiable concentrate (25% AI)	96 h LC_{50}	1.1 μg/L	Jolly et al. 1978
Largemouth bass *(Micropterus salmoides)*	Emulsifiable concentrate (25% AI)	96 h LC_{50}	8.5 μg/L	Jolly et al. 1978
Amphibian				
Bullfrog tadpoles *(Rana catesbeiana)*	Emulsifiable concentrate (25% AI)	96 h LC_{50}	7 033.0 μg/L	Jolly et al. 1978

Crustaceans				
Crayfish *(Procambarus clarkii)*				
newly hatched mean wt. 0.05 g	Emulsifiable concentrate (25% AI)	96 h LC_{50}	0.39 µg/L	Jolly et al. 1978
juvenile mean wt. 0.5 g	Emulsifiable concentrate (25% AI)	96 h LC_{50}	0.62 µg/L	Jolly et al. 1978
Lobster *(Homarus americanus)*	Technical material (92% AI)	lethal threshold	7.0 µg/L	Zitko et al. 1979
	Technical material (92% AI)	lethal threshold	0.68 µg/L	McLeese et al. 1980
	Technical material (92% AI)	96 h LC_{50}	0.73 µg/L	McLeese et al. 1980
Shrimp *(Crangon septemspinosa)*	Technical material (92% AI)	lethal threshold	0.29 µg/L(sic)	McLeese et al. 1980
	Technical material (92% AI)	96 h LC_{50}	0.13 µg/L(sic)	McLeese et al. 1980
Amphipod *(Gammarus pulex)*	Emulsifiable concentrate (25% AI)	24 h LC_{90-95} after 1 h exposure	1 µg/L	Muirhead-Thompson 1978
Aquatic Insects				
Mayfly nymph *(Baetis rhodani)*	Emulsifiable concentrate (25% AI)	24 h LC_{90-95} after 1 h exposure	1 µg/L	Muirhead-Thompson 1978
Caddisfly larvae				
(Hydropsyche pellucidula)	Emulsifiable concentrate (25% AI)	24 h LC_{90-95} after 1 h exposure	100 µg/L	Muirhead-Thompson 1978
(Brachycentrus subnubilis)	Emulsifiable concentrate (25% AI)	24 h LC_{90-95} after 1 h exposure	1 µg/L	Muirhead-Thompson 1978
Blackfly larva *(Simulium equinum)*	Emulsifiable concentrate (25% AI)	24 h LC_{90-95} after 1 h exposure	5 µg/L	Muirhead-Thompson 1978
Mosquito larva *(Culex quinquefasciatus)*	Technical material	24 h LC_{50}	1.4 µg/L	Mulla et al. 1978b
		24 h LC_{90}	2.5 µg/L	Mulla et al. 1978b

Some data on the effects of permethrin on nontarget organisms have been collected during field testing against mosquito larvae (Mulla and Darwazeh 1976; Mulla et al. 1975, 1978). Applications of permethrin at dosages between 11 and 112 g AI/ha to shallow ponds caused severe effects on mayfly and dragonfly nymphs and depressed chironomid midge larvae, copepod, and ostracod populations for short periods. A few other field studies have been carried out in ponds but are not yet reported or available for reference. One study currently under progress at the University of Guelph involves introducing selected concentrations of permethrin into enclosures (limno-corrals) set up in small lakes and then studying the effects on zooplankton and other organisms (personal communication K.R. Solomon).

After reviewing the available efficacy and environmental impact data generated to that point in time, FPMI decided in the fall of 1979 to approach provincial agencies responsible for forest protection to see if they were interested in carrying out experimental permethrin applications in 1980 under their own operational treatment conditions. Eventually, experiments were carried out in three provinces to evaluate the efficacy of single and double permethrin applications at 17.5 g AI/ha. The Ontario Ministry of Natural Resources treated 89- and 190-ha blocks with single and double applications respectively, the Quebec Service d'Entomologie et de Pathologie treated two 400-ha blocks with each spray regime, and the Forest Pest Management Institute treated 600-ha blocks at each rate in New Brunswick. Aquatic, terrestrial, and chemical residue studies were carried out in some of the spray blocks in Quebec, with aquatic invertebrate, terrestrial arthropod, and small mammal studies conducted by FPMI (Kreutzweiser 1982); bird monitoring studies by the Quebec Department of Recreation, Fish and Game; water and foliage residue analyses collected by the Quebec Department of Energy and Resources; and additional chemical residue sampling done by Chipman Inc.

The spray blocks selected in New Brunswick were intentionally chosen to contain portions of Atlantic salmon, *Salmo salar* L., nursery streams, so that environmental impact data on this important fish species could be generated to supplement data previously collected on brook trout, *Salvelinus fontinalis* (Mitch.). To collect as much data as possible and to meet the requirements and concerns of regional environmental regulatory agencies, a number of investigators from FPMI, the Maritimes Forest Research Centre, Chipman Inc., and Montreal Engineering Company Ltd., (under contract to FPMI and Chipman Inc.) were involved in the environmental impact studies. The studies carried out by these groups are reported together in this report and the contributing authors and the portions of the work conducted by them are indicated in the individual sections.

This report is primarily intended for the use of reviewers required to assess the hazards posed by permethrin to forest ecosystems and make decisions regarding its future use. As their criteria for evaluating hazard may differ from those of the various authors, as much raw data as possible have been provided in appendices to allow for comprehensive individual scrutiny and interpretation.

II. STUDY SITE DESCRIPTION

P. Kingsbury
Forest Pest Management Institute

Studies were carried out within the Young's Brook watershed, a stream system flowing into the Nashwaak River about 35 km north of Fredericton in central New Brunswick. Two 600-ha treatment blocks were located along the Glenco Road, which runs east from Highway 8 north of the village of Nashwaak Bridge. The blocks measured 4 km x 1.5 km and were centered on substantial portions of Young's Brook and McCallum Brook with their long axes oriented in an east-west direction (Fig. 1).

Single application block

The block covering a large portion of McCallum Brook received a single application of permethrin. The nature of the stream within the area treated was variable, ranging from shallow gravel riffles to bedrock bottom to slow deep areas behind beaver dams. Almost the entire stretch of stream was characterized by an extensive stream bank growth of alder, *Alnus rugosa*, which provided cover over a good portion of the stream surface (Fig. 2). Aquatic macrophytes, primarily aquatic mosses and watercress, were abundant in some portions of the stream. The stream valley within this block was generally modest in slope and depth. Forest cover over the single application block was fairly continuous and moderately heavy in nature with a predominantly closed canopy.

The locations within McCallum Brook of sampling sites referred to in later sections are illustrated in Fig. 4. Water and sediment residue sampling sites were closely associated with caged fish sites. The Surber sampling site was located in a riffle area just south of the access road. Drift and artificial-substrate sampling were carried out downstream of the Surber sampling site closer to the point where McCallum Brook flows out of the treatment block.

Double application block

The double application block was oriented with its long axis paralleling Young's Brook so that approximately 5 km of the mainstream bisected the block, with McCallum Brook and a number of minor tributaries flowing into the north side of the block. The upstream portion of Young's Brook within the double application block was similar to McCallum Brook in terms of being variable in nature, heavily covered by a stream bank canopy of alders and backed up into a fairly deep silt-bottomed pool in at least one location. Below the confluence with McCallum Brook the nature of Young's Brook changed considerably and wide-open, hard-bottomed riffles interspersed with deeper sections of moderate flow predominated. Much of the cover along this portion of stream was conifers in a dead or severely defoliated condition (Fig. 3). Most of Young's Brook within the double application block flowed through a deep, steep-walled stream valley where

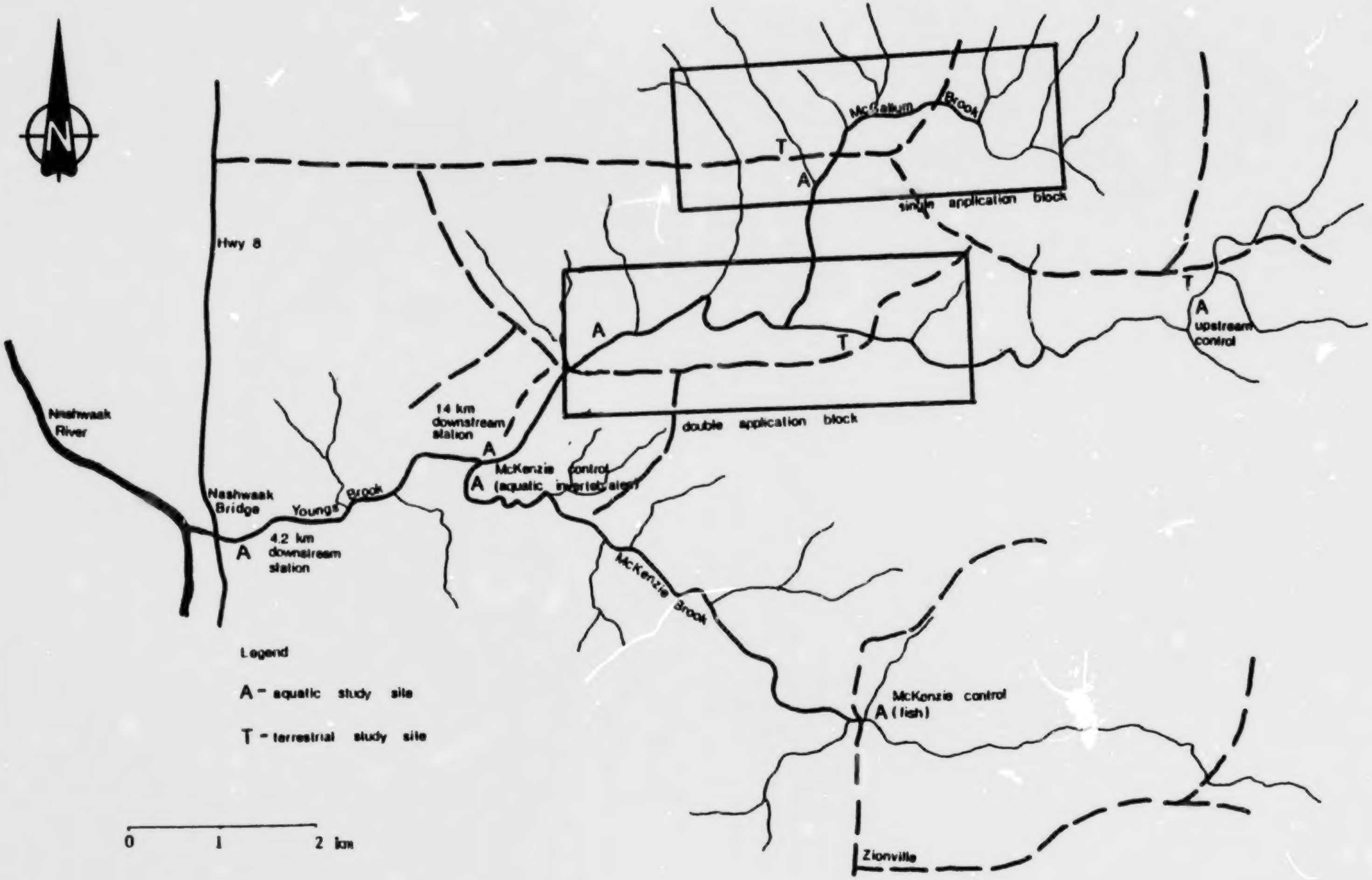
N
Hwy 8
Nashwaak River
Nashwaak Bridge
Youngs Brook
A 4.2 km downstream station
14 km downstream station
A
McKenzie control
A (aquatic invertebrates)
McKenzie Brook
A McKenzie control (fish)
Zionville
A
T
McCallum Brook
single application block
T
A
double application block
T
A upstream control
Legend
A - aquatic study site
T - terrestrial study site
0
1
2 km

Figure 1. Permethrin treatment blocks and study sites, Young's Creek watershed, New Brunswick, 1980.

Fig. 2. Fish population sampling site (No. 3) in McCallum Brook, single application block, late May 1981.

Fig. 3. Fish population sampling site (No. 1) in Young's Brook, double application block, late May 1981.

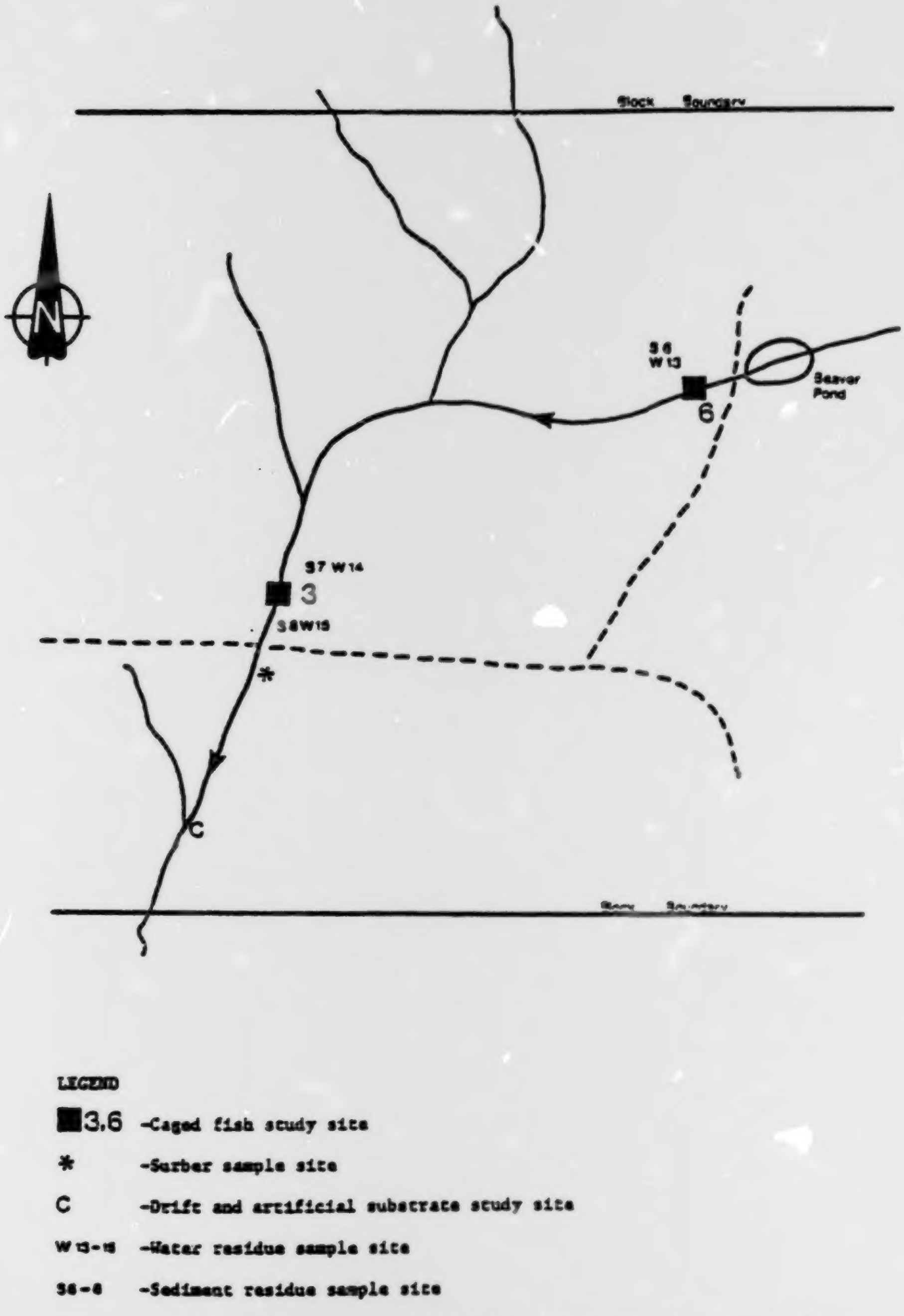
Block Boundary
N
S6
W13
Beaver Pond
6
S7 W14
3
S8W15
*
C
Block Boundary
LEGEND
3,6 -Caged fish study site
* -Surber sample site
C -Drift and artificial substrate study site
W13-15 -Water residue sample site
S6-8 -Sediment residue sample site

Figure 4. Sample sites within McCallum Brook, permethrin single application block, New Brunswick, 1980.

Figure 4. Sample sites within McCallum Brook, permethrin single application block, New Brunswick, 1980.

the most of the mature conifers within the block were found. Much of the remainder of the block had been clear-cut within the past decade, resulting in large open areas and areas thickly grown up in trembling aspen, *Populus tremuloides* Michx., and pin cherry, *Prunus pensylvanica* L.f.

Water residue sampling sites within the double application block were closely associated with caged fish study sites (Fig. 5), but sediment residue sampling was confined to the upstream portion of Young's Brook as little sediment was present below the confluence with McCallum Brook. Water residues were also sampled at several sites downstream of the treated block, including three sites near the 1.4-km downstream drift sampling site and one site just below the confluence of Young's Brook and its largest tributary, McKenzie Brook.

Upstream control area

An unsprayed portion of Young's Brook 2.2 km upstream from the double application block and an area of adjacent forest served as control sites for aquatic and terrestrial impact studies. This portion of Young's Brook was narrow and shallow, but fast flowing with a hard bottom of small rocks and gravel. Much of the stream surface was overhung by streambank alder, *Alnus* spp. and considerable growth of aquatic mosses was present on the stream bed. The stream valley was deeply cut and steep sided. The adjacent terrestrial study site was located on an old clear-cut, well above the stream valley. This area was dotted with scattered clumps of regenerated balsam fir, *Abies balsamea* (L.) Mill., pin cherry, and trembling aspen, but predominated by a wide-open canopy.

McKenzie Brook control areas

Separate control sites for aquatic studies were established on McKenzie Brook, a major tributary flowing into Young's Brook from a southeast direction about 1.5 km downstream from the double application block. Aquatic invertebrate samples were collected just above the junction of the two streams, while fish studies were conducted about 6 km upstream where McKenzie Brook was accessible from the Zionville road. McKenzie Brook was variable in nature with sections of shallow riffles, silty ponds behind beaver dams, and varying amounts of stream cover over different stretches. It appeared to have more sand and boulder bottom types than Young's Brook.

Downstream study sites

Aquatic invertebrates were also sampled at two sites on Young's Brook downstream from the treated areas. The first of these was 1.4 km downstream of the double application block just above the confluence with McKenzie Brook, and the second was 4.2 km downstream of the treated block and just upstream of where Young's Brook passes under Highway 8 and flows into the Nashwaak River at Nashwaak Bridge. Young's Brook is wide, shallow, hard bottomed and almost completely exposed to the sky at both of these downstream sites.

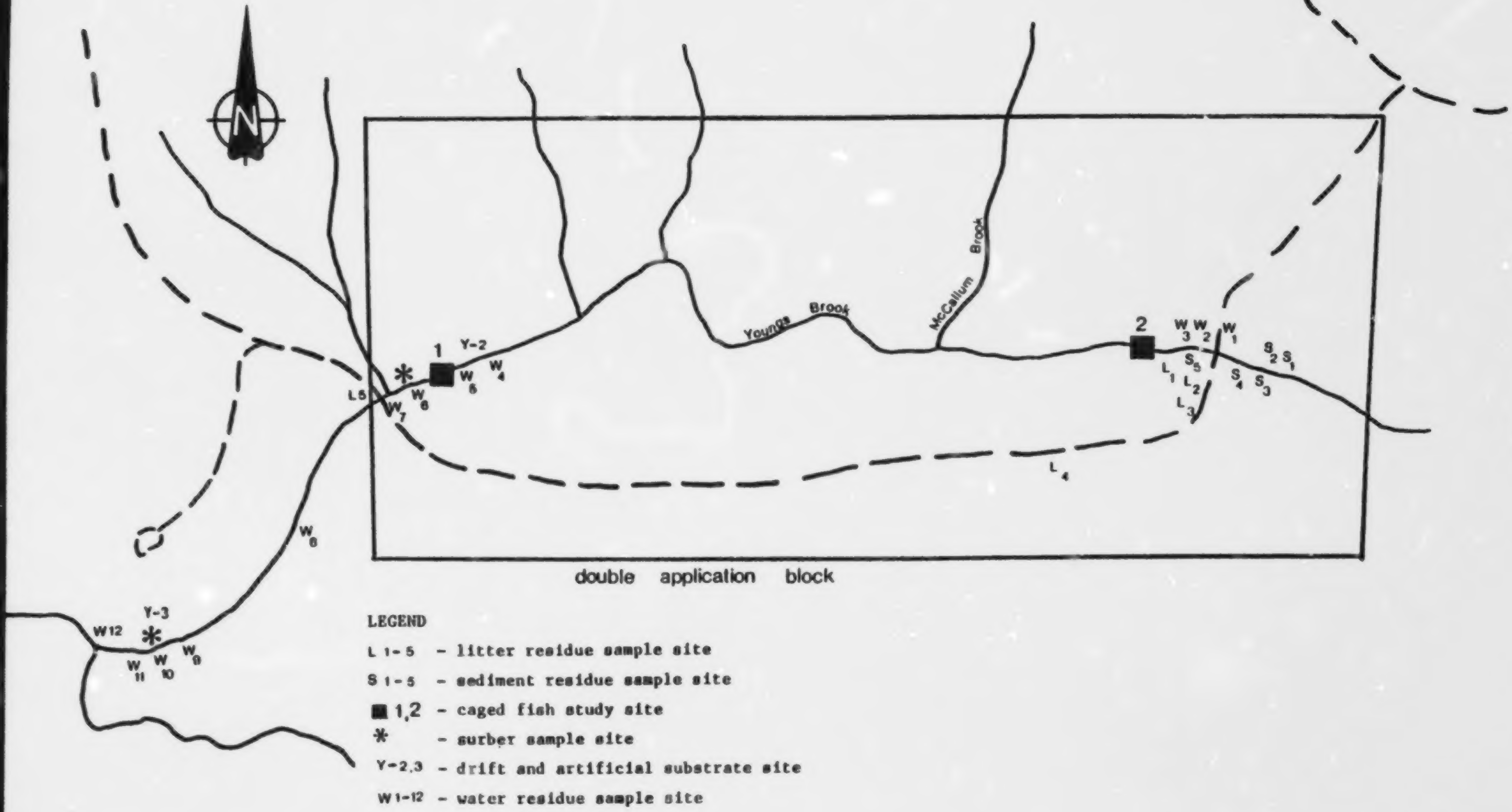
N
1
Y-2
W_5
W_4
*
L5
W_6
W_7
Youngs Brook
McCallum Brook
2
W_3 W_2 W_1
S_5 S_2 S_1
L_1 L_2 L_3
S_4 S_3
L_4
W_8
double application block
Y-3
W12
W_9
W_{10}
W_{11}
LEGEND
L 1-5 - litter residue sample site
S 1-5 - sediment residue sample site
■ 1,2 - caged fish study site
* - surber sample site
Y-2,3 - drift and artificial substrate site
W1-12 - water residue sample site

Figure 5. Sample sites within Young's Brook, permethrin double application block, New Brunswick, 1980.

III. APPLICATION PROCEDURES AND DEPOSIT ASSESSMENT

P. Kingsbury and B. Zylstra
Forest Pest Management Institute

The permethrin treatments were applied under the direction of FPMI's Field Efficacy group, who also carried out and reported efficacy studies in the treated blocks (Zylstra and Obarymskyj 1981). FPMI personnel set out sample units in various study sites to measure the deposit of emitted spray after each application.

Application procedures

The permethrin was mixed with insecticide diluent 585 and a tracer dye and applied to the treatment blocks at an application rate of 17.5 g AI/ha in an emitted volume of 1.40 L/ha. The actual spray mix applied on each occasion to the 600-ha block consisted of:

Permethrin OSC 500 g AI/L*	22.2 L
Shell diluent 585**	847.3 L
Automate B red dye+2	17.7 L

The treatments were applied by a Cessna Agtruck equipped with four AU 3000 micronair atomizers. The rate of flow through the micronairs was set at 23.6 L/min. The aircraft applied the treatments from a height of between 25 and 30 m above ground level, at an air speed of 160 km/h, with a resultant swath width of approximately 60 m. The date, time (Atlantic Daylight), and prevailing weather conditions during the period of each spray application are presented in Table 3.

Deposit Assessment

Methods

The deposit of emitted spray products at various sampling sites was measured by setting out 10 x 10 cm Kromekote® cards mounted on aluminum plates immediately prior to spray application and collecting them about 1 hour after spraying was completed. Deposit was also assessed in efficacy sites by colorimetric determination of the amounts of dye landing on glass slides set out under sample trees scattered across each treated block (Zylstra and Obarymskyj 1981). Spray deposits on Kromekote® cards were assessed in the FPMI laboratory in Sault Ste.Marie by counting and sizing stains to determine droplet density (drops/cm^2) and droplet spectra characteristics. The volume of emitted spray material deposited was also determined by using spread factor values for the formulation to calculate the volume of spray products contained in the deposited droplets.

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* Chipman Inc., Stoney Creek, Ont.

** supplied by Forest Protection Ltd., Fredericton, N.B.

+ Morton Williams Ltd., Ajax, Ont.

Table 3. Date, time and prevailing weather conditions during permethrin treatments to experimental blocks in New Brunswick, 3-7 June 1980

	Single application block	Double application block	
		First application	Second application
Date	3 June	3 June	7 June
Time	1850-2035	0618-0805	0600-0750
Temperature (°C)	14	7	2
Relative humidity (%)	57	93	65
Inversion	0	+	+
Wind speed (km/hr)	0-5	0-6	2-5
Wind direction	SE	NE	N
Cloud cover	3/10	3/10	0/10

Deposit samplers at stream sites were set out in an alternating pattern of sample units set right on the stream bank under typical stream bank cover and units set on platforms on stakes driven into the stream bed in midstream. Sample units at terrestrial knockdown sites were placed on the ground beside knockdown buckets, while sample units at efficacy sites were set out on platforms on top of short stakes as described by Randall (1980).

Results and discussion

Similar mean volume deposits were measured from the efficacy sites scattered across the treatment blocks after each permethrin application (Table 4). There were, however, noticeable differences in the density of droplets and mean droplet size deposited, particularly with the second treatment of the double application block when larger numbers of smaller droplets were deposited than during the other applications. The single application block received the lowest mean deposit in terms of both the density of droplets deposited, the measured volume deposited, and the relatively small mean droplet diameter deposited. This block was treated under the warmest, driest and least stable conditions of the three applications (Table 3), which probably accounts for it receiving the lowest deposit, since formulation and application equipment did not vary for the three treatments.

Table 4. Measured deposit of emitted spray products* at various study sites of the permethrin experimental program in New Brunswick, 1980

	Number of deposit samplers	Mean no. of drops/cm^2 (range)	Mean droplet diameter ( )	Mean vol. L/ha (range)
Single application block				
Stream	10	4.1 (1.7–7.8)	58.0	0.07 (0.03–0.15)
Efficacy sites**	100	6.2	71.8	0.10 (0.02–0.26)
Double application block				
1st application				
Stream (Site 1)	10	3.6 (1.8–5.5)	79.4	0.16 (0.07–0.25)
Terrestrial knockdown sites				
Pin cherry	10	5.8 (1.3–11.3)	76.2	0.23 (0.04–0.48)
Balsam fir	10	2.5 (0.3–2.8)	65.8	0.04 (0.01–0.12)
Efficacy sites**	82	7.0	90.0	0.13 (0.01–0.42)
2nd application				
Stream (Site 1)	10	13.2 (8.1–25.7)	46.8	0.14 (0.06–0.69)
Stream (Site 2)	10	48.2 (32.9–84.5)	41.1	1.08 (0.50–2.62)
Terrestrial knockdown site				
Pin cherry	10	17.4 (5.1–31.4)	73.0	0.59 (0.09–1.22)
Efficacy sites**	82	14.0	66.7	0.11 (0.03–0.38)
1.4 km Downstream Site				
1st application	4	1.9 (1.6–2.1)	57.8	0.03 (0.02–0.04)
2nd application	3	1.0 (0.7–1.2)	52.2	0.01 (0.01)

* Emitted volume 1.40 L/ha.

** Data provided by the Forest Pest Management Institute's Field Efficacy Group.

Deposits recorded at environmental impact study sites were generally similar to mean deposits on efficacy sites, except that the mean droplet size deposited was usually smaller than at efficacy sites. This reflects the more sheltered location of deposit samplers at environmental impact sites. Samplers at efficacy sites were placed in clearings cut beside sample trees, while no surrounding vegetation was removed from environmental impact study sites and overhead vegetation filtered out larger droplets. Deposit at the caged fish and fish population site (Fig. 5, Site 2) in Young's Brook, measured after the second treatment of the double application block, was much higher in terms of the density of droplets and volume deposit measured than any other study site or the mean for all efficacy sites following this treatment. This site is situated at the bottom of a deep, steep sided stream valley, and it is speculated that prevailing meteorological conditions, application procedures, and the extreme topography combined in some fashion to concentrate the spray cloud in the bottom of the stream valley at this site after this application. This effect was also noticed in the high droplet density (24.7 drops/cm^{2}*) deposited at the efficacy stations located right along the stream bank at this site compared to a mean of 10.5 drops/cm^{2} at all other efficacy sites. Although deposit in the stream was not measured at this site during the first application to this block, it was probably not greatly different than at other sites on that occasion as the same efficacy sites recorded a droplet density (6.4 drops/cm^{2}*) similar to the mean for all other efficacy sites (7.2 drops/cm^{2}*).

After both permethrin treatments to the double application block, small numbers of small droplets were deposited on samplers set out along the shore of Young's Brook 1.4 km downstream from the block, close to the confluence with McKenzie Brook. Thus, both this downstream site and probably McKenzie Brook received some permethrin from aerial drift contamination during the treatment of this block on both spray days.

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* Data provided by the Forest Pest Management Institute's Field Efficacy group.

IV. RESIDUE STUDIES

G. Wood
Chipman Inc.

Samples of stream water, stream sediment, and forest litter were collected by Chipman Inc. from sites in and around the permethrin-treated blocks to quantify the levels and persistence of permethrin residues present. Samples of native fish collected for fish diet studies (Section VII) and crayfish held in cages for mortality studies (Section VIII) were also analyzed for permethrin residues. All sample extractions and analyses were carried out by chemists from Chipman Inc., but the Analytical Chemistry group at FPMI participated in the analysis of permethrin standards and pre-extracted environmental samples to verify the accuracy of calibration of the analytical equipment used.

METHODS

Residue sample collection, extraction, and analysis procedures employed in this study are briefly summarized below and are presented in greater detail in Appendix I.

Sample collection

Stream water samples were collected from within the single (Fig. 4) and double application blocks (Fig. 5) and from several sites located downstream from the double block. Each sample was collected in two 1-L amber glass bottles held approximately 10 cm below the surface of the stream. Fifty mL of the collected water were decanted from each bottle and replaced with hexane (distilled in glass). The bottles were securely capped, shaken vigorously, and transported to the field lab for extraction and subsequent analysis.

Samples of native fish collected in both treatment and control blocks for analysis of feeding activity were retained for determination of permethrin residues. The eviscerated fish were sorted by species, and in some instances age class, and wrapped in approximately 50-g lots in tinfoil, then frozen in clear polyethylene bags, and stored until processed. Crayfish held in screened cages at treatment and control sites were removed 13 days after the second spray, wrapped in clear polyethylene bags, and frozen until analyzed.

Stream sediments from within the single and double application blocks were sampled with an aluminum cup-shaped dipper (5 cm dia. x 6.4 cm length) immersed on edge into the sediment to a depth of 2.5 cm (half diameter). The dipper was advanced slowly until filled with sediment that was then placed in a 750 mL screw cap jar and frozen. Five such samples were collected from an area of 2 m^2 at each site and combined.

A Miniskipek Sediment Sampler was used as a template (17.8 x 10 cm) for cutting sections of litter to a depth of 2.5 cm from the forest floor in the double application block. Five of these sections were cut from an area of 10 m^2 and combined as one sample at each site. The litter samples were then placed in polyethylene bags and frozen until subsequent analysis.

Analytical procedures

Water samples were field extracted as soon after collection as possible, usually within 12 hours, with a total of 700 mL of distilled hexane. This was later evaporated to dryness, dissolved in 10 mL of hexane, and analyzed directly by electron capture on a Tracor 550, gas chromatograph to a detection limit of 0.01 μg/L (ppb).

Eviscerated fish samples of 15-50 g were thawed in distilled water and extracted in a Sorval Omni-Mixer in 150 mL of 4:6 acetone:hexane in the presence of 200 g of anhydrous sodium sulfate. The extract was filtered under vacuum, evaporated to dryness, then redissolved in 10 mL hexane. A 1-mL aliquot was cleaned on silica gel, evaporated to near dryness, and redissolved to 2 mL with hexane for subsequent gas chromatographic analysis [detection limit of 0.005 μg/g (ppm)]. Permethrin residues in crayfish were analyzed in the same manner as that described for fish.

For determination of residual permethrin levels in stream sediment and forest litter, 50 g of a composite sample were extracted with 200 mL of 2:8 acetone:hexane in the presence of anhydrous sodium sulfate in a Sorvall Omni-Mixer. The extract was vacuum filtered and washed with water to remove the acetone. The hexane was then dried with anhydrous sodium sulfate and an aliquot equivalent to 25 g of sample was evaporated to dryness on a rotary evaporator. The residue was redissolved in 10 mL of hexane and a 2-mL aliquot was cleaned on a Florisil column. The eluant fraction containing permethrin was concentrated, then rediluted to 10 mL and analyzed on the gas chromatograph. Permethrin residues in stream sediment were measured to a detection limit of 0.007 μg/g (ppm), whereas forest litter samples were analyzed with a detection limit of 0.003 μg/g (ppm).

Confirmation of permethrin residues

Residue analyses were based on total unresolved isomer determination using equivalent retention times as the main criterion for identification (i.e., permethrin's two isomers eluted as a single peak with equal retention times in both samples and standards). If a residue was apparently detected in a sample taken from a site where residues had been previously absent, or from a control site or from a prespray, then the identity of that residue was confirmed or rejected by an isomer separation confirmation technique using a different set of chromatographic parameters, which separated the two isomers of permethrin. If the suspect component identified as a residue resolved into two peaks with the same retention times as the standard permethrin isomer peaks, then the identity was confirmed. If the suspect peak did not resolve, then the identity was proven false. This methodology was used for confirmation of residues in all sample matrices and verified that all residues measured were in fact permethrin.

RESULTS

Following the exchange of permethrin standards between the Chipman Inc. and FPMI analytical laboratories and calibration of the analytical equipment, sixteen extracted water samples from streams treated in Quebec in 1980 were analyzed by each laboratory (Kreutzweiser 1982). Levels of permethrin residues in water extracts reported independently by the two laboratories agreed closely, confirming the generally high degree of precision with which the residue analyses were performed. Over half of the values reported by the two laboratories differed by 0.02 µg/L or less, which is considered the limit of detection by FPMI chemists. The greatest discrepancy reported was a value reported 17.5% higher by Chipman than FPMI.

Residual permethrin in water samples collected from sites (W1-7) within the double application block after the initial application peaked at 0.13-0.31 µg/L and fell to nondetectable levels (0.01 µg/L) in all but one location (W7) well within 24 hours (Table 5). Samples from a stretch 0.2-1.4 km below the double application block (W8-11) contained peak concentrations of 0.08-0.13 µg/L ½ hour after the application and returned to nondetectable levels in all but one (W9) 9-hour postspray sample. No detectable levels of the pesticide were found in the stream at the confluence with McKenzie Brook (W12) after the initial application.

Peak levels of permethrin residues in water sampled from the block were substantially higher (0.22-0.96 µg/L) following the second application and permethrin residues in water persisted in low concentrations (0.04 µg/L) at most sample sites for at least 48 hours. Water samples from the downstream sites (W8-12) also contained higher residue levels (0.13-0.25 µg/L) following the second application than those measured after the first spray, but residues fell to nondetectable levels within 12-24 hours. A sample (W12) collected at the confluence with McKenzie Brook 1 hour after the second application contained 0.13 µg/L permethrin but subsequent samples (6 and 12 hours postspray) did not contain detectable amounts of residual pesticide at this site.

Permethrin residues in water disappeared rapidly following treatment of the single application block (Table 5). Initial concentrations ranged from 0.07 to 0.23 µg/L, but within 6 hours no measurable quantities of pesticide were present in the samples. One of three prespray samples collected from the single application block indicated a permethrin concentration of 0.05 µg/L, but this sample was discarded before confirmation by isomer separation could be made.

Mean levels of 0.02 and 0.03 µg/g permethrin were detected in the tissue of brook trout and juvenile Atlantic salmon collected in the double block 1 day after the second application (Table 6). Twenty-five days later samples of brook trout did not contain measurable concentrations of pesticide, whereas the mean value of residue levels analyzed from composite

Table 5. Permethrin residues (µg/ℓ) in water from double application (Young's Brook) and single application (McCallum Brook) treatments, York County, New Brunswick, 1980.

	Double Application - Young's Brook							Downstream from double block					Single Application		
	Upper Section			Lower Section				0.2 km	1.4 km	1.4 km	1.4 km	1.5 km	McCallum Brook		
Sampling Regime Sample Number	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Pre-spray	-	-	-	-	N.D.	N.D.	N.D.	N.D.	-	-	-	-	0.05	N.D.	N.D.
First application															
½ hr post-spray	0.28	0.29	0.30	0.16	0.30	0.31	0.13	0.08	0.11	0.11	0.13	N.D.	0.07	0.23	0.13
6-9 hr	N.D.	0.03	0.05	N.D.	N.D.	N.D.	0.03	N.D.	0.04	N.D.	-	N.D.	N.D.	N.D.	N.D.
14-16 hr	N.D.	N.D.	0.03	N.D.	N.D.	N.D.	0.04	N.D.	N.D.	N.D.	N.D.	-	N.D.	N.D.	N.D.
24-28 hr	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.04	N.D.	-	-	-	-	N.D.	N.D.	N.D.
84 hr	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.04	N.D.	-	-	-	-	-	-	-
Second application															
½-1 hr post-spray	0.66	0.66	0.64	0.52	0.77	0.96	0.22	N.D.	0.22	0.22	0.25	0.13			
6 hr	0.03	0.06	N.D.	0.07	0.10	0.07	0.15	0.08	0.07	0.07	0.08	N.D.			
12 hr	N.D.	N.D.	N.D.	0.03	0.04	N.D.	0.07	0.05	N.D.	N.D.	N.D.	N.D.			
24 hr	N.D.	N.D.	0.03	N.D.	N.D.	0.04	N.D.	N.D.	-	-	-	-			
48 hr	N.D.	0.04	0.04	N.D.	0.04	0.04	N.D.	N.D.	-	-	-	-			

" - " indicates no sample taken
N.D. - none detected
Limit of detection 0.01 µg/ℓ (ppb)

Table 6. Permethrin residues (µg/g) in eviscerated native fish and whole caged crayfish from study streams, York County, New Brunswick, 1980

	Brook trout	1+ salmon	2+ salmon	Slimy sculpins	American eels	Crayfish
Untreated control - Young's Brook Upstream						
Prespray	ND (7)* ND (7)* ND (7)*	ND (7)	ND (1)	-	-	-
4 days postspray	ND (2) ND (2) ND (4)	-	ND (3) ND (2) ND (3)	ND (10)	-	-
13 days postspray	-	-	-	-	-	ND (7)
29 days postspray	ND (4)	-	ND (7) ND (7)	ND (10)	-	-
73 days postspray	ND (7) ND (7)	ND (7) ND (7)	ND (7) ND (7)	ND (7)	-	-
Single application - McCallum Brook						
Prespray	ND (1) ND (7) ND (7)	ND (7) ND (7)	-	ND (7)	-	-
3 days postspray	ND (1) 0.008 (1) 0.010 (3) 0.013 (3) Mean 0.008	ND (9)	ND (1) ND (4) 0.022 (3) Mean 0.007	0.020 (11)	ND (1) 0.020 (1) Mean 0.010	-
13 days postspray	-	-	-	-	-	ND (7)
28 days postspray	0.011 (5)	ND (6)	ND (3)	ND (7)	-	-
73 days postspray	ND (1) ND (1)	ND (7) ND (7)	ND (7) ND (7)	ND (7)	-	-
Double application - Young's Brook						
Prespray	ND (7)	ND (7)	ND (7)	-	-	-
1 day postspray (second application)	ND (1) 0.012 (1) 0.023 (2) 0.024 (2) 0.031 (2) 0.035 (1) Mean 0.021	0.030 (5)	ND (2) ND (7) 0.097 (2) Mean 0.032	ND (7)	ND (7) ND (7)	-
13 days postspray	-	-	-	-	-	ND (7)
25 days postspray	ND (1) ND (1)	ND (7)** 0.190 (7)** Mean 0.095**		ND (3) ND (4)	-	-
69 days postspray	-	ND (7) ND (7)	ND (7) ND (7)	ND (7)	-	-

* Residues from separate samples, mean number of individuals pooled to make up sample given in parenthesis.

** 1+ and 2+ salmon combined in samples because of the small weight of 1+ salmon obtained.

ND - none detected.

Limit of detection 0.005 µg/g.

salmon samples was considerably higher (0.0 µg/g) than immediately postspray. No permethrin residues were found in samples of slimy sculpins or American eels, and 2½ months after the double application, no residues were detected in any fish samples.

Residual permethrin levels in fish sampled from the single application block were noticeably lower than in fish from the double application block (Table 6). Brook trout sampled 3 days after treatment contained 0.008 µg/g permethrin and virtually the same amount (0.011µg/g) 28 days postspray. One plus salmon (salmon in their 2nd year) contained no detectable pesticide, while 2+ salmon contained mean residues of 0.007 µg/g 3 days after the application and none in subsequent samples. Slimy sculpins and American eels from the 3-day postspray collection were found to contain residual permethrin residues of 0.020 µg/g and 0.010 µg/g, respectively, but samples of both species did not contain detectable residues 28 days postspray. No pesticide residues were found in any of the fish samples collected 73 days after the application.

Crayfish in screened cages in the single and double application blocks collected 13 days after the second application to the double block contained no detectable permethrin.

Residual permethrin at levels above the limit of detection was only found in a few samples of stream sediment. One of a total of 15 sediment samples taken from the double block and 2 of a total 9 samples from the single application block contained low concentrations of pesticide (Table 7).

Permethrin residues in forest litter from the double application block were considerably higher and more stable. Results presented in Table 7 indicate peak accumulations as high as 0.157 and 0.750 µg/g, 1-4 days after the second application. Seventy-five to ninety-five percent of the permethrin in litter was lost over the next 70 days, but residues ranging from 0.027 to 0.037 µg/g were still present at this time. Although litter sampling after the initial application was not extensive, results from samples taken after the second application demonstrate that the second treatment contributed significantly to the accumulation of residual permethrin in litter.

DISCUSSION

Permethrin residues in stream water samples from within and below the double application block following the initial application did not exceed 0.31 µg/L, and had virtually disappeared within 6 hours. Trace amounts (0.03-0.04µg/L) of pesticide continued to be detected in samples from one site within the block (W7) for the duration of the sampling period prior to the second application (84 hours postspray) and may have been the result of the physical stream characteristics at that site. Whereas all other water collections from within the block were taken from comparatively straight and uninterrupted stretches of stream, the W7 site was

Table 7. Permethrin residues (μg/g wet weight) in stream sediment and forest litter from treatment areas, York County, New Brunswick, 1980

	Stream Sediment								Forest Litter				
	Double application block					Single application block			Double application block				
	S1	S2	S3	S4	S5	S6	S7	S8	L1	L2	L3	L4	L5
Prespray	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
First application													
1 day postspray						-	-	-	-	-	0.035	ND	ND
4 days postspray						-	-	-	-	-	0.044	ND	ND
10 days postspray						ND	ND	ND					
37 days postspray						ND	ND	0.007					
72 days postspray						ND	ND	0.024					
Second application													
1 day postspray	-	-	-	-	-				0.157	0.157	0.200	ND	ND
4 days postspray	-	-	-	-	-				0.071	0.121	0.750	ND	0.034
6 days postspray	ND	ND	ND	ND	ND				-	-	-	-	-
35 days postspray	ND	ND	0.017	ND	ND				0.049	0.035	0.031	0.024	0.020
68 days postspray	ND	ND	ND	ND	ND				0.037	0.035	0.028	ND	0.027

" - " indicates no sample taken.

ND - none detected.

Limit of detection in sediment 0.007 μg/g and in litter 0.003 μg/g (ppm).

located immediately below a slow-flowing and heavily silted bend in the stream. Field observations recorded immediately after the application indicated that this location served as a collection pool for dead invertebrates being carried down the stream and may have had a similar effect on permethrin residues.

Peak concentrations of residual pesticide in the water samples after the second application were 2-3 times higher, and of greater duration than after the first application. This concurs with larger spray deposits measured in the stream after the second application (Section III).

The relatively low pesticide deposit measured and the dense foliage canopy characteristic of McCallum Brook in the single application block were reflected by the low and rapidly disappearing permethrin residues in water collected from that block. Pesticide concentrations did not exceed 0.23 µg/L and were not detectable within 9 hours of the application. Because experimental application blocks have no record of previous permethrin applications, the prespray residue of 0.05 µg/L obtained from McCallum Brook may have resulted from contamination during extraction or analysis.

The levels of permethrin residues attained in the streams did not appear to present a risk of direct mortality to the fish species present. Peak residues in the water after the applications were 5.2-38.5 times lower than a 96-h lethal threshold to juvenile Atlantic salmon of 5.0 µg/L reported by McLeese et al. (1980), and 8.3-61.5 times lower than the 24-h LC_{50} value of 8.0 µg/L for rainbow trout determined by Mulla et al.(1978a). In some instances however, the peak residues in water samples from the treated streams approached the 24-h LC_{90-95} after one hour exposure values of 1.0 µg/L for the invertebrates *Baetis rhodani, Brachycentrus subnibiis,* and *Gammarus pulex* (Muirhead-Thomson 1978), although the concentrations fell well below this LC_{90-95} value within 6 hours. Residues in water samples collected near the caged crayfish in the double application block, following both treatments, approached or exceeded the 96-h LC_{50} levels of 0.39 µg/L and 0.62 µg/L reported for newly hatched and juvenile crayfish (Jolly et al. 1978), but persisted above these levels for less than 6 hours.

The peak concentrations of residual permethrin found in the streams were generally slightly lower than those previously reported after permethrin applications at the same dosage to flowing water. Kingsbury and Kreutzweiser (1979, 1980) reported that permethrin residues in flowing water had diminished to nondetectable levels well within 12 to 24 h, while in the present and concomitant studies (Kreutzweiser 1982) detectable levels in some sampling locations persisted for at least 48 hours and, in one instance, for 84 hours. However, the limit of detection of permethrin residues by gas chromatography has been reduced from 0.2 µg/L in 1979, and 0.05 µg/L in 1980 to 0.01 µg/L in the present study. Consequently, water samples previously reported as containing no detectable concentrations of permethrin may have fallen within the range of detection now possible.

Residual permethrin in water samples from the present study did not persist in concentrations above 0.05 µg/L beyond 24 h. Reduced levels of pesticide residues in water samples from sites located 0.2-1.4 km below the double application block agree with similar results observed in previous studies (Kingsbury and Kreutzweiser 1979, 1980). This is probably largely due to loss of permethrin from stream water via adsorption onto organic materials and dilution of contaminated stream water as the pesticide flows downstream, especially below confluences with major untreated streams. Minimal residues (none detected after the first application and 0.13 µg/L in one sample immediately after the second) found in samples taken below the confluence with McKenzie Brook, 1.5 km below the double application block (site W12), substantiate indications observed by Kingsbury and Kreutzweiser (1980) that residual permethrin is rapidly diluted over a short distance below the confluence with a major untreated tributary.

Concentrations of permethrin found in the tissues of brook trout collected in the double block one day after the second application (0.020 µg/g) were 20.8-90.9 times higher than the peak residue levels detected in the stream water following the second application. Residues in juvenile Atlantic salmon were somewhat greater with concentrations 31.2-136.4 times higher than immediate postspray water residue levels. In static testing of the toxicity of permethrin to juvenile Atlantic salmon under laboratory conditions, Zitko et al. (1977) and McLeese et al (1980) found concentration factors (concentration in fish/concentration in water) of 43 after a 17-hour exposure and 22.6 after a 12.5-hour exposure to the salmon. These values were obtained from tests of permethrin concentrations in water 20-1000 times higher than those encountered in the streams of the present study. Concentration factors in salmon exposed to permethrin under laboratory conditions increased sharply with exposure to lower concentrations (Zitko et al. 1977; McLeese et al. 1980). Equilibrium values not much greater than the maximum values found in these laboratory studies (55 for a 96 h exposure to 22 µg/L and 73 for a 89 h exposure to 6.9 µg/L) appear likely. The concentration factors found in the present field study indicate that values of this magnitude will also be found under field conditions.

Although residues in brook trout from the double application block had disappeared by the 25-day postspray collection date, the mean concentration of 2 composite salmon samples was 0.095 µg/g, substantially higher than the 1-day postspray sample value of 0.03 µg/g. This increase, and the lack of decline of residues in brook trout from the single application block over the same period, may indicate a persistence or continued accumulation of residues in fish tissues well beyond the initial peak exposure, possibly induced by minimal but prolonged exposure to residual permethrin in certain sections of stream such as the one described earlier for site W7. If the increases can be attributed to prolonged exposure, it is apparent that the phenomenon was infrequent or localized because 5 of the 7 salmon and trout samples analyzed from the 25-day postspray collection in both blocks contained no detectable levels of permethrin. The brief exposure to substantial permethrin concentrations in the water (generally less than

12 hours), and the ability of the fish to eliminate the pesticide suggest that residues in fish tissues are unlikely to accumulate and persist over a 25-day period. Zitko et al. (1977) and McLeese et al. (1980) report that juvenile salmon in static bioassays had eliminated 58.3-67.2% of the pesticide after 4 days of constant exposure.

Permethrin residues in fish from the double application block were noticeably higher than those in fish collected from the single block, which reflects both the higher water residues and the double exposure to the pesticide.

As has been found in previous experimental applications to forest streams (Kingsbury and Kreutzweiser 1980; Kreutzweiser 1982), permethrin was only occasionally found in detectable quantities in stream sediments in both the single and double application blocks, in spite of its property of strongly adsorbing onto and firmly binding to organic soils (Graham-Bryce 1980; Kaufman et al. 1981). This apparent discrepancy can be attributed to the nature of the stream sediments sampled and the small quantities of permethrin applied per unit area. Sediments in forest streams are generally very low in organic content, consisting primarily of sand and gravel; this is particularly true of salmonid nursery streams because of the detrimental effects of silt on salmonid eggs buried in stream bottoms. Although sediment sampling sites were intentionally chosen in areas with as much organic sediment as possible, sediment samples still consisted mostly of fine sand, as much of the organic material present on top of the sand was so light that it became suspended in the stream and was lost during the sampling process. Quantities of permethrin on the small proportion of organic material were generally not sufficient to provide detectable quantities per unit weight of samples, which were made up of predominantly inorganic sediments.

Accumulations of permethrin in forest litter from the double application block were considerably greater and more stable than in sediment. Residues diminished to concentrations ranging from 0.020 to 0.049 µg/g within 35-37 days, but remained at that level for the duration of the sampling period (68-72 days postspray). This level of persistence in forest litter approximates that reported by Kingsbury and Kreutzweiser (1980), but is of substantially greater duration than that found by Kreutzweiser (1982).

V. STREAM INVERTEBRATE DRIFT STUDIES

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The immediate impact of the permethrin treatments on aquatic invertebrates was monitored with drift nets placed at various sites in Young's Brook and McCallum Brook. Terrestrial arthropods present in drift were also monitored to supplement the study of knockdown of arboreal and flying arthropods (Section X).

METHODS

Drift nets were set at five sites in the Young's Brook system: McCallum Brook near the outflow of the single application block, Young's Brook about 2.2 km upstream of the treated areas, near the outflow of the double application block, 1.4 km downstream, and 4.2 km downstream of the double application block. Three or four nets 8 cm wide with 240 μ apertures were used at all sites, except in McCallum Brook and 4.2 km downstream in Young's Brook where single nets 32 cm wide with 363 μ apertures were used. Differences had to do with availability of equipment and served no functional purpose. All nets sampled a vertical column from the stream bottom up to and including the surface. Nets were set for various times, up to 30 min; shorter times were used to reduce sample size during periods of heavy drift. Water velocity through nets at all drift sampling sites was measured on 9 June, and the values obtained were used to calculate the volume of water sampled on all dates. Time and equipment limitations prevented measurement of water velocity with each drift sample, but because of low variations in stream levels and the wide differences in drift catch, it is felt that this did not introduce an important source of error. Drift catches were expressed as organisms/m^3 of water to compensate for different flows, different set durations, and different net sizes. Use of two mesh sizes did not introduce error because changes in catch, not absolute catches, were compared among sites. Catches of terrestrial arthropods were expressed as both number/15-min, 32 cm wide drift sample, and as arthropods/m^3, but the former was used in analysis.

RESULTS

Aquatic invertebrates

The density in drift of aquatic invertebrates at the various sites on 3 June is summarized in Table 8. Both the density and the variation in density at the untreated upstream site were low because all samples were taken in daylight; density ranged from 1 to 9 invertebrates/m^3.

After the permethrin application that began at 1850 h, 3 June, drift density increased sharply in McCallum Brook near the outflow of the single application block (Table 8). The highest density recorded was 1548 invertebrates/m^3. Drift density remained high until 2115 h when sampling

Table 8. Drift density in aquatic invertebrates/m^3 at Young's Brook and McCallum Brook, 3 June 1980

Time	Control	Single Block*	Double Block**	1.4 km downstream	4.2 km downstream
0500			3		7
0515	4	4			
0530				2	
0615	9				1
0630			<1	<1	
0715	2				
0730			1264	1881	
0745					178
0815	1				
0830			4111	2659	
0845					1775
0900	3	2	2819		
1015	2			3903	
1030			2867		885
1315	2				
1330			1528	1497	
1345					447
1715	4				
1730			655	780	
1745					201
1900	6		539		
1915		1548			
1930		713			
2000			1079		
2030		787			
2100	2				
2115		1383	622		

* Spray applied between 1850 h and 2035 h.
** Spray applied between 0620 h and 0805 h.

ended for the day. By 5 June and subsequent dates, morning drift samples indicated a return to low drift densities comparable with those before treatment (Table 9).

Simuliid larvae and chironomid larvae were the first to increase in drift after the treatment; peak density occurred in a sample at 1950 h, 1 h after spray began. Plecoptera naiads, mainly *Leuctra* spp., and Ephemeroptera naiads, mainly *Baetis* spp., were also strongly affected, but their drift densities did not peak immediately, increasing quickly at first, and then slowly over the next 2½ h. Other taxa were either less affected or were not prone to drift and thus do not show in the drift record. Water mites, Hydracarina, which are usually relatively resistant to chemical contaminants, gradually increased from a background density of 1 to more than $8/m^3$ in postspray samples. All but a few invertebrates in postspray drift were dead. Drift density data for the control site is detailed in Appendix II, Table 1, and for the site near the outflow of the single application block in Appendix II, Table 2.

Before spray, drift density at the site on Young's Brook near the outflow of the double application block was comparable with that at the control station (Tables 8 and 9). After the first application began, drift density was 1000 x pretreatment density, and ½ h after spraying ended it was about 4000 x pretreatment density. Samples indicated a decline thereafter, with a small resurgence at 2000 h, which was during the spraying of the single application block. A sample taken the morning of 5 June, 2 days after treatment, gave a drift density above background, but probably not significantly so (Table 9).

Simuliid larvae were the first to reach peak numbers in drift, followed closely by chironomid larvae, Plecoptera (mainly *Leuctra* spp.), Ephemeroptera (mainly *Baetis* spp.), and Heptageniidae, Trichoptera, Coleoptera, and Hydracarina. Although drift of the mayfly genus *Ephemerella* and the caddisfly family Hydropsychidae increased in the first sample after spraying, density continued to increase for 2 h after spraying ended. By the time of the last sample of the day at 2110 h, drift had not yet returned to normal. All but a few invertebrates in postspray drift were dead. Drift density, by taxon and time of net set, for the site near the outflow of the double application block on 3 June, the date of the first application, is detailed in Appendix I, Table 3.

Drift density at the untreated upstream control on the day of the second spray application to the double application block (Table 10) was comparable with that on the day of first application (Table 8) and throughout the sample period from 27 May to 12 August (Table 9). At the site at the outflow of the double treatment block, the prespray density was unusually large. The second sample of the day was begun before spraying started and continued after. It demonstrated an immediate increase in drift density (Table 10). The highest density reached was about 1000 x background, and occurred almost 2 h after spray began and near the time it ended. Drift density declined steadily thereafter, and 2 days later was near background density (Table 9).

Table 9. Drift density in aquatic invertebrates/m^3 at Young's Brook and McCallum Brook between 0830 and 1200 h on various dates

Date 1980	Upstream control	Single block	Double block	1.4 km downstream	4.2 km downstream
27 May	6	2	2	1	-
28 May	1	<1	1	1	<1
29 May	2	<1	2	1	1
31 May	1	1	2	3	1
2 June	2	1	2	2	1
3 June	3	2	2867	3903	885
3 June PM*		1548			
5 June	2	5	8	9	3
7 June	2	-	1693	1329	15
9 June	3	2	7	14	33
12 June	1	<1	1	1	<1
16 June	7	<1	<1	<1	1
19 June	1	<1	1	1	<1
23 June	1	<1	1	1	<1
2 July	<1	<1	<1	4	<1
10 July	1	<1	1	5	<1
17 July	1	<1	3	<1	<1
29 July	2	<1	5	2	1
12 August	1	1	2	1	<1

* Evening sample taken during treatment of the block.

Table 10. Drift density in aquatic invertebrates/m^3 at Young's Brook 7 June 1980. Spray applied between 0600 h and 0750 h

Approx. time	Upstream control	Double block	1.4 km downstream	4.2 km downstream
0500	3	29	3	
0515				
0530				1
0600	1	360	4	
0645	2	598	39	
0700				1
0745		2545	2037	
0800				1
0845	2	1007		
0945	2	1692	1329	
1000				15
1245	2	1165	1228	
1315				12
1645			685	
1700		328		
1745	2			5

All taxa seen in drift after the first spray application were present after the second spray application. The high prespray drift density was due mainly to similiid and chironomid larvae. Increased densities of most taxa in drift occurred simultaneously. Trichoptera were notably fewer, and *Baetis* spp. were scarce. As after the first application, *Ephemerella* subgenus *Eurylophella* peaked about 2 h after the application ended. Water mites and chironomid larvae were twice as numerous at peak density as they were after the first application. Drift density by taxon and time of net set, 7 June, for the control site is shown in Appendix I, Table 4, and for the site at the outflow of the double application block in Appendix I, Table 5.

After the first application an increase in drift similar to that at the outflow of the double application block occurred 1.4 km downstream (Table 8). This increase was about the same magnitude and began almost simultaneously. At the site 4.2 km downstream, drift density also increased, but not as much and apparently later.

After the second application an increase similar to that at the outflow of the double application block again occurred 1.4 km downstream (Table 10), but did not reach dramatic levels until at least 1 h later than within the block. At the station 4.2 km downstream, a small increase in drift occurred 3 or 4 h later than the increase at the outflow of the double application block.

Terrestrial invertebrates

All terrestrial invertebrates taken in drift nets were arthropods. Most were insects, but there were some spiders. Numbers of terrestrial arthropods in drift at the upstream control ranged from 0 to 25/15-min sample on the first spray day, 3 June (Table 11). At the outflow of the single application block, terrestrial arthropods in drift rose from 25 and 43 before, to 768 and 288 during and immediately after spray, then dropped sharply less than 1 h after the spray. At the outflow of the double application block, drift rose sharply after spray and remained high for the rest of the day, except at 0830 h when there were none recorded (Table 11). It is suspected that some terrestrial arthropods were present in this sample, but were overlooked due to the massive numbers of aquatic organisms present. A second and even higher peak in terrestrial invertebrate drift occurred within the double application block at 2000 h during treatment of the upstream single application block. Numbers remained elevated on 5 June (Table 12) and were still higher than at any other site early in the morning of 7 June, when the second permethrin application caused a second very large increase in terrestrial drift, which persisted through 9 June (Tables 12 and 13). Large terrestrial drift increases occurred 1.4 km downstream from the double application block after each treatment and persisted throughout the day of application. Terrestrial drift increases were much smaller 4.2 km downstream and only reached levels substantially higher than control levels between 2 and 9 h after the first application.

Table 11. Terrestrial arthropods in 15 min drift samples from Young's Brook and McCallum Brook, 3 June 1980

Approx. time	Control	Single block*	Double block**	1.4 km downstream	4.2 km downstream
0500			3		0
0515	5	25			
0530				1	
0615	24				0
0630			2	3	
0715	2				
0730			128	48	
0745					4
0815	5				
0830			0	0	
0845					16
0900		43	522		
0915	8				
1015	5		576		
1030				446	96
1315	8				
1330			288	64	
1345					0
1715	16				
1730			240	161	
1745					64
1900	25		288		
1915		768			
1930		432			
2000			1056		
2030		288			
2100	0				
2115		0			

* Spray applied between 1850 h and 2035 h.

** Spray applied between 0620 h and 0805 h.

Table 12. Terrestrial arthropods/15-min sample in drift from Young's Brook between 0830 and 1200 h on various dates

Date	Upstream control	Double application block*
27 May	407	38
28	85	7
29	62	7
31	21	23
2 June	5	14
3	17	232
5	18	156
7	25	128
9	23	73
12	12	23
16	72	12
19	23	23
23	41	43
2 July	19	8
10	47	38
17	76	179
29	87	575
12 August	95	90

* Sprays applied 3 June and 7 June.

Table 13. Terrestrial arthropods/15-min sample in drift from Young's Brook 7 June 1980. Spray applied between 0600 h and 0750 h

Approx. time	Control	Double block	1.4 km downstream	4.2 km downstream
0500	8	23	0	
0515				
0530				2
0600	2	36	2	
0645	5		0	
0700		75		0
0745			34	
0800		597		1
0845	9	48		
0945	6		124	
1000		249		15
1245	8		269	
1300		898		7
1645			299	
1700		32		0
1745	1			

DISCUSSION

The permethrin applications to the blocks containing parts of McCallum and Young's Brooks caused massive disturbances of aquatic invertebrates resulting in catastrophic drift for 3-12 h. A negligible proportion of the drift was living invertebrates. Density in drift of almost all taxa increased. Comparable pesticide-induced invertebrate drift following experimental permethrin applications has been documented by Kingsbury (1976b), Kingsbury and Kreutzweiser (1979, 1980b), and Kreutzweiser (1982).

Of the three permethrin treatments, the single application to McCallum Brook caused the least dramatic drift increases, probably because of the lower permethrin deposits recorded in this block (Section III) and lower permethrin residues found in the water (Section IV). An increase in invertebrate drift in Young's Brook in the double application block 13½ h after the first application corresponded to the spray on the single application block, which took place in the evening. It indicates either an impact of residual permethrin from McCallum Brook, or drift of pesticide-affected invertebrates through the double application block, or both. McCallum contributed about half the volume of flow in Young's Brook below their confluence within the double application block, and permethrin in McCallum Brook could have significantly increased the permethrin residue in Young's Brook. Water samples were not frequent enough to state with confidence that this did or did not occur (Section IV).

Despite higher spray deposits in the double application block and higher permethrin residues in Young's Brook after the second application, invertebrate drift did not reach the density found after the first spray. Similar results from experimental double applications of permethrin have been reported (Kingsbury and Kreutzweiser 1979; Kreutzweiser 1982), and probably indicate that the impact of the first application was such that susceptible invertebrates were significantly reduced, or that the greater proportion had been removed.

In general, the main portion of the catastrophic drift consisted of insects: Simuliidae, Chironomidae, Plecoptera, Ephemeroptera, and Trichoptera. Among the first to appear after each spray were the Simuliidae, which live in exposed sites in rapidly flowing water. Most taxa followed quickly, their relative numbers corresponding to their relative numbers in benthos, but also to the exposure of their habitat. Thus for example, stonefly larvae, *Leuctra* spp., which frequent rock surfaces, were abundant in drift, but heptageniid mayfly nymphs, which live under rocks and may become entrapped when distressed, were underrepresented. Water mites in drift generally peaked later than other taxa, a result we do not find surprising because mites are generally more resistant to many toxicants.

Invertebrate drift increases 1.4 km below the double application block following the first application were similar to those at the outflow of the block, but may not have resulted entirely from downstream transport of residual permethrin or of dead and distressed invertebrates. The wind was from the northwest on 3 June, and aerial drift of insecticide at the sampling site was noted by several workers who smelled the oil carrier. Increases in invertebrate drift at the 4.2 km downstream site were much smaller, and only reached dramatic levels after the first application, indicating that residual permethrin had diminished to the extent that the impact on aquatic invertebrates was much less than it was upstream. However, there were no residue analyses of water from that far downstream, and it is not known if the increase was due to downstream drift of insecticides or of invertebrates that had been poisoned upstream.

VI. STREAM BOTTOM FAUNA STUDIES

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Standing crop of bottom fauna, or benthos, was monitored near the same sites as those selected for sampling drift of benthos. Samples were taken before, between, and after the treatments using three methods. Artificial substrates were used by the Maritimes Forest Research Centre (MFRC) to sample benthos, and to determine relative changes in benthos numbers and composition over time. Other artificial substrates were used by MFRC to sample larvae of Simuliidae, or blackflies, because of their exposed habitat. Simuliid larvae would be expected to receive greater exposure to permethrin than other taxa if permethrin were adsorbed on fine suspended particles in the water because they are collector-filterers. Surber (1936) samplers were used by FPMI to directly sample standing crop of benthos in riffle areas in the same general areas as other types of sampling.

METHODS

Sampling sites were established in the upstream control stretch of Young's Brook (Fig. 1), near the outflow of McCallum Brook from the single application block (Fig. 4), near the outflow of Young's Brook from the double application block (Fig. 5), and 1.4 km downstream from the double application block (Fig. 1). These sites were located as close to the drift-sampling sites as they could be without causing interference. Sampling with Surbers and sampling with artificial substrates were within 50 m of each other at all sites except in McCallum Brook, where Surber samples were taken approximately 500 m upstream.

To sample simuliids, 10 x 10 cm unglazed quarry tiles were placed on the bottom in riffles so that one corner projected upward into the current, after the method of Lewis and Bennett (1974). These were colonized very rapidly, but were never collected after less than 24 h of colonization time. Eleven tiles were sampled at each site on most occasions, but fewer were used on occasions when some tiles were dislodged by the current or removed by curious fishermen. Larvae were scraped from the tiles into 70% ethanol with a piece of glass and the tiles were returned to the stream. Larvae were sorted, counted, and identified in the laboratory.

The artificial substrate samplers were the rock balls of Eidt (1981), and consisted of 1 kg of crushed rock (13-19 mm screen size) tightly wrapped in nylon seine material with 3 x 7 mm apertures (Fig. 6). They were placed in depressions in the stream bed by removing a similar-sized rock so that approximately half of each sampler was recessed into the stream bed. The locations were selected for moderate current, usually near the lower ends of pools, but where receding water would not expose

Fig. 6. Surber sampler being used to sample benthic invertebrates in Young's Brook.

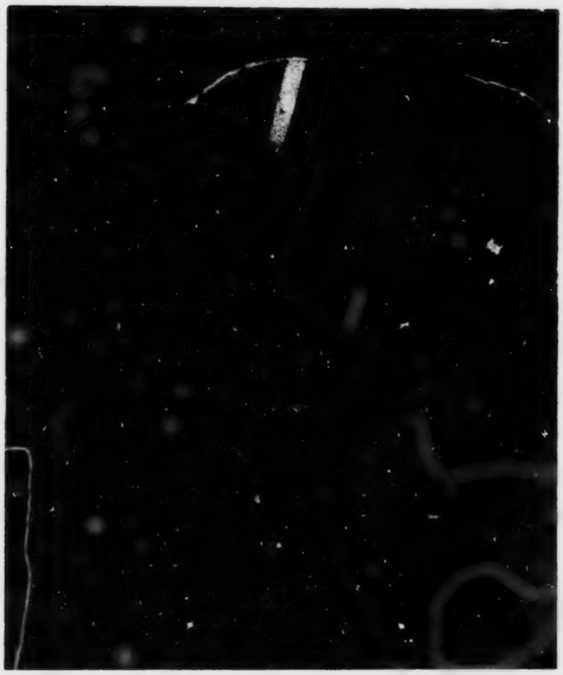

Fig. 7. Artificial substrate sample in sampler in place on the stream bed of Young's Brook. The flagging tape attached to facilitate locating and retrieving the sampler has been colonized by blackfly larvae.

them. All the rock balls were in the stream for at least 4 weeks to allow sufficient time for colonization. Five were collected on each sampling date using a D-frame net with a plastic foam seal at the bottom of the frame and a bag with 0.2-mm apertures. The samples were washed over a series of soil sieves down to 125 μm apertures, and subsequently sorted, identified, and tabulated as mean numbers with standard deviations of 5 samples.

The Surber sampler frame covered 0.093 m^2 of stream bottom, and the net had approximately 1.1-mm apertures. Four replicates were taken by dislodging organisms within the area delineated by the frame from approximately the top 5 cm of stream bottom in riffles at each site (Fig. 7). The invertebrates were immediately sorted from the debris and preserved in 70% methanol to be subsequently identified, counted, and tabulated as means with standard deviations of 4 samples.

The diversity index of Shannon and Weaver (1963) was calculated for each rock ball and Surber sample site, and date. This index takes into account both the numbers of species present and their relative abundance in the samples.

RESULTS

Standard deviations of mean numbers of simuliid larvae from quarry tiles were extremely high. Although a drop in numbers of larvae at the control site (Table 14) is of doubtful statistical significance, a logical trend in numbers occurred. Numbers were high on the first three dates, but declined shortly after 9 June coincidentally with a period of pupation

Table 14. Simuliidae larvae* colonizing quarry tiles placed in treatment and control streams, York County, N.B., 26 May to 12 September 1980

Sample date	Control	Single application block**	Double application block***	1.4 km below double block	4.2 km below double block
26 May	62 ± 36	79 ± 52	711 ± 474	278 ± 491	112 ± 80
5 June	204 ± 176	5 ± 6	37 ± 46	115 ± 226	17 ± 17
9 June	113 ± 63	1	1	2 ± 1	8 ± 13
2 July	13 ± 21	0	0	2 ± 2	1 ± 2
21 July	22 ± 10	1 ± 5	45 ± 34	188 ± 168	2 ± 3
12 August	29 ± 32	4 ± 9	29 ± 89	64 ± 79	9 ± 20
12 September	6 ± 8	3 ± 5	8 ± 6	36 ± 29	2 ± 3

* Mean number with standard deviation of 10 or 11 replicates.

** Treated with 17.5 g AI/ha permethrin at 1850 h on 3 June 1980.

*** Treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 to 0750 h on 7 June 1980.

and emergence of *Simulium* spp., of which *Simulium tuberosum* was the most abundant species. At the station in the single application block, *Simulium* spp., of which *S. tuberosum* and *S. corbis* together formed the greater part of the population, declined sharply 2 days after the spray and blackfly larvae had all but disappeared at the site by 9 June. At the station in the double application block, *Simulium* spp., especially *S. corbis*, which were abundant in the prespray sample, were reduced by nearly 95% after the second spray. To a lesser degree, coincidental declines occurred 1.4 km and 4.2 km downstream of the double application block.

Benthos standing crop, as determined using Surber samplers and rock balls, generally declined in the double application block following the treatments. Results were less definite in the single application block, even though spray-induced drift was heavy.

Numbers of Ephemeroptera (Fig. 8) did not change significantly in the control or in the single application block except that an increase was indicated in October by rock ball samples. In the single block, ephemerellids did not decline after treatment, and being the most numerous family of mayflies, masked possible declines in baetids, heptageniids, and leptophlebiids. In the double application block, numbers of Ephemeroptera larvae were clearly diminished following the first treatment and further diminished by the second. This effect is emphasized by a manifestation of the same effect 1.4 km downstream and to a lesser extent 4.2 km downstream. The decline affected all four families, although Ephemerellidae, especially in Surber samples, seemed more resistant. A late-season increase in Ephemeroptera occurred in the control, the single application block and the double application block in rock ball samples (and presumably at the downstream stations where a late 1980 sample was not taken). A late-season increase did not occur in the Surber samples, either because the net mesh was too large to retain the small larvae, or because the last sample was about 3 weeks earlier than the last rock ball sample of 1980.

A decline in Plecoptera larvae occurred in the double application block, and both downstream stations in both rock balls and Surbers (Fig.9). Although the decline was not statistically significant at any station, the trend was consistent. Populations in the control were high and remained consistently so. Numbers in both rock balls and Surbers in the single application block were not affected. A late-season increase in numbers was apparent in both types of samples at most stations. In all rock ball samples, *Leuctra* spp. larvae outnumbered all other genera of Plecoptera combined in all samples; they consistently constituted more than 90% of the Plecoptera.

It is not possible to distinguish any changes in numbers of Trichoptera larvae in rock balls or Surber samples that can be attributed to the treatments (Fig. 10). It is also not possible to identify significant changes at the family level because there were wide differences in population structures by family at the various sites. According to rock ball

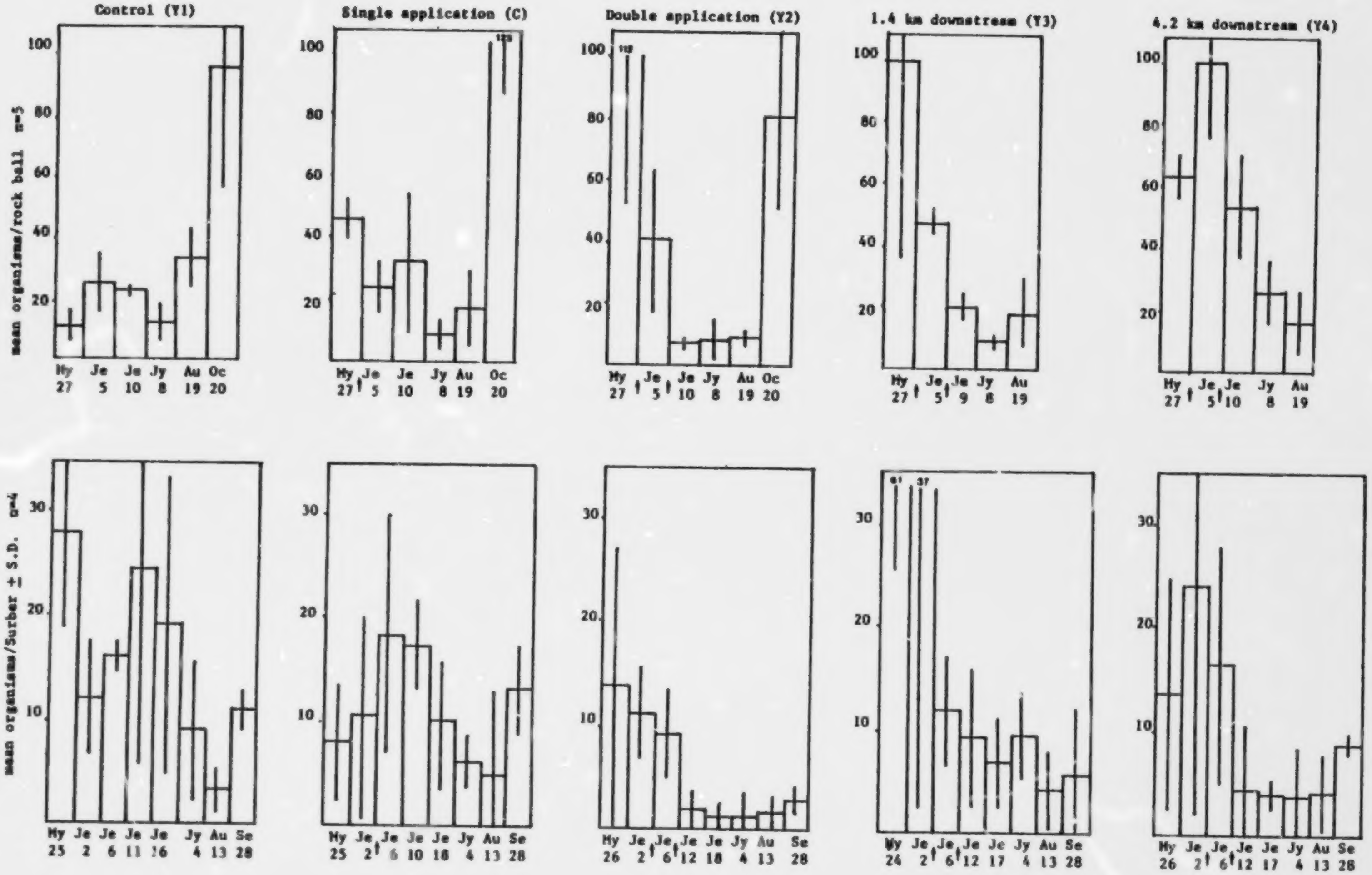

Figure 8. Ephemeroptera nymphs collected in artificial substrates and Surber samples in permethrin treated and untreated control streams, York County, New Brunswick, 25 May to 28 September, 1980. Arrows between sample dates denote permethrin treatments.

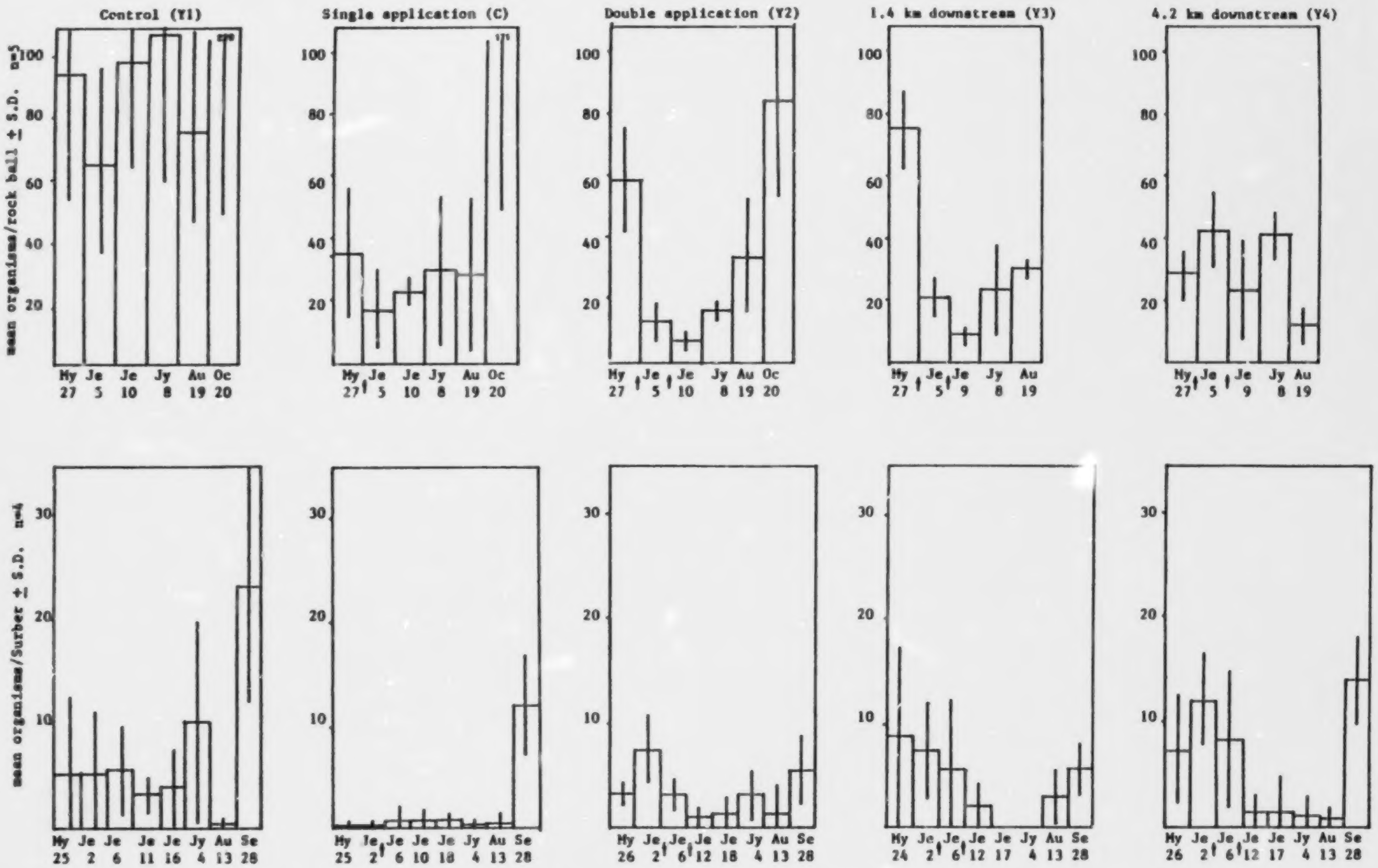

Figure 9. Plecoptera nymphs collected in artificial substrates and Surber samples in permethrin treated and untreated control streams, York County, New Brunswick, 25 May to 28 September, 1980. Arrows between sample dates denote permethrin treatments.

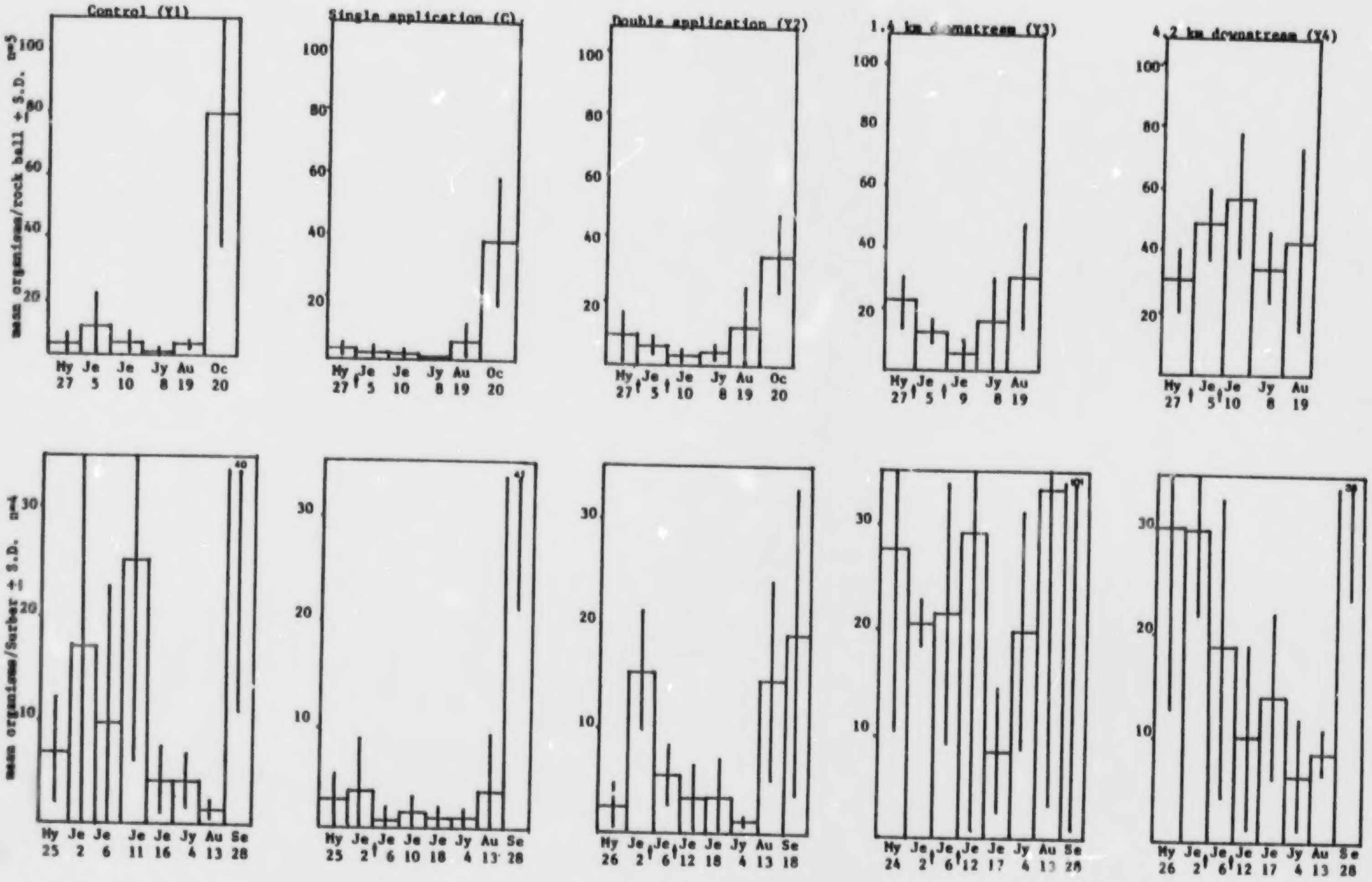

Figure 10. Trichoptera larvae collected in artificial substrates and Surber samples in permethrin treated and untreated control streams, York County, New Brunswick, 26 May to 28 September, 1980. Arrows between sample dates denote permethrin treatments.

samples, brachycentrids dominated at the control station whereas hydropsychids and lepidostomatids dominated at both stations within spray blocks. The Surber samples also indicated that brachycentrids dominated at the control station, but in the treatment blocks, glossosomatids and rhyacophilids were most abundant on most dates. This result is partly because glossosomatids were scarce in rock balls, an obviously unsuitable substrate for them. For some unknown reason, brachycentrids were dominant in Surbers from the 4.2 km downstream station, even though few were collected in rock balls. This station was in a stretch vastly different from that of the control station, more than 10 km upstream.

A drop in numbers of chironomidae in rock balls 10 June, although not statistically significant, is consistent among the double application and the two downstream stations (Fig. 11). Chironomidae are normally abundant and involve many species with various life histories. Whatever other impacts on chironomids may have occurred are indistinguishable at the family level in both rock balls or Surber samples.

Blackfly larvae in rock balls at the double application station diminished from more than 600 per ball 27 May to 13 after the first spray and to 0 and 6 in the two samples immediately following the second spray. In the control sample they numbered from 36 to 345 over the same period with no apparent trends. In Surber samples, blackflies were too few in prespray samples to infer changes due to the treatments.

Detailed analyses of rock-ball artificial-substrate samples to family for most insects are given in Appendix III. Similar data for Surber samples are given in Appendix IV.

Diversity expressed as Shannon-Weaver indices was relatively stable at the control station; in both rock balls (Table 15) and Surber samples (Table 16) diversity declined in early July and was highest toward the end of the summer. The trend was similar at the single application station, but at the double application station a decline was apparent from 10 June, after the second application, through to August in both types of samples. Lower diversity also generally occurred in rock balls and Surber samples at both downstream stations from mid-June to August.

DISCUSSION

Both Surber and rock ball samples in McCallum Brook indicated no reduction of bottom fauna as a result of the single permethrin application. Some organisms followed patterns similar to those at the upstream control, declining in numbers, especially towards late summer, but returning to, or in most instances greatly exceeding, prespray numbers by the end of the season. Reductions must have occurred because animals were lost in spray-induced drift, but our rock ball and Surber samples were not sensitive enough to show it. Only blackfly larvae, sampled from quarry tiles, were shown to have measurably and substantially decreased as a result of the treatment. Numbers of blackfly larvae remained low in all subsequent

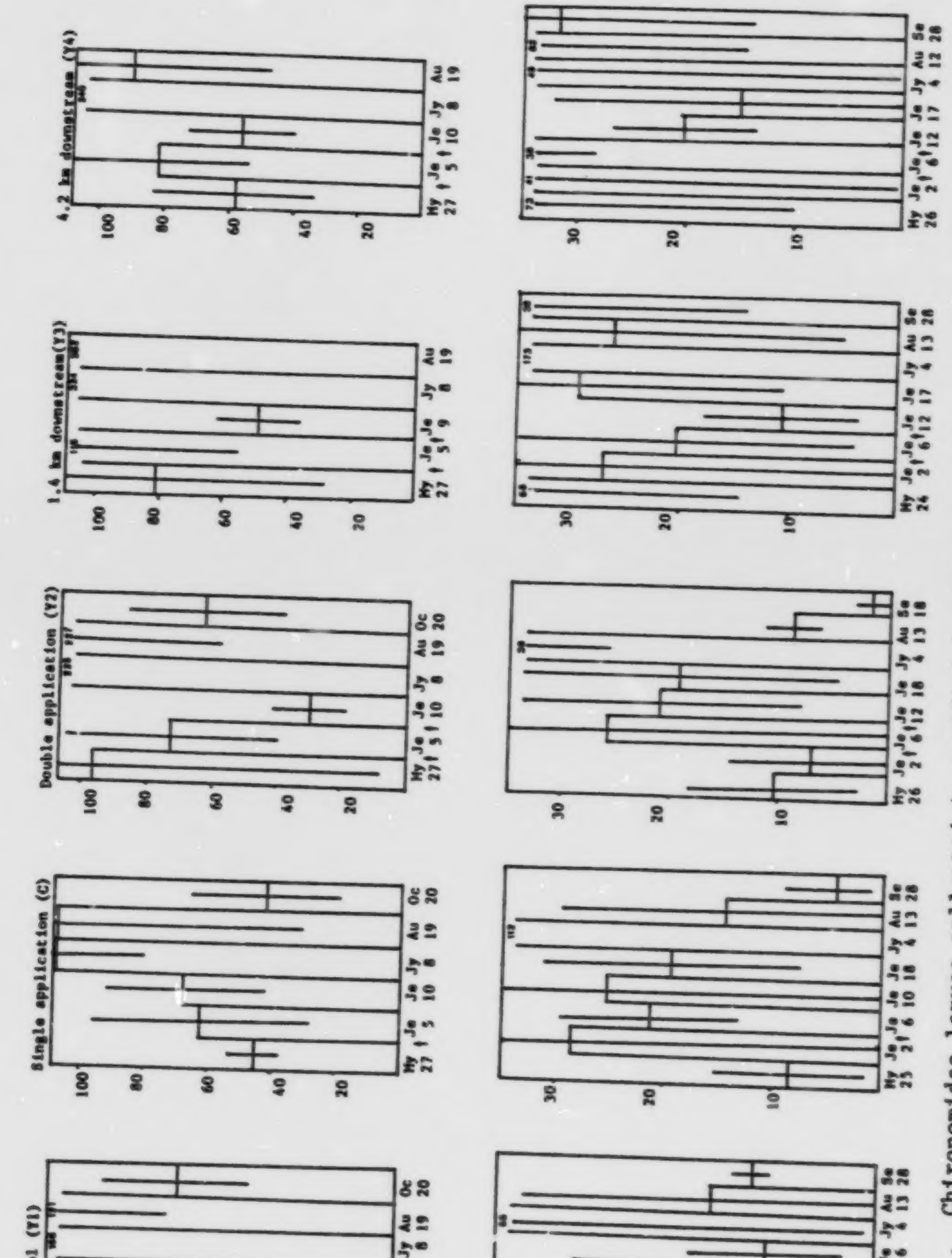

Figure 11. Chironomidae larvae collected in artificial substrates and Surber samples in Permethrin treated and untreated control streams, York County, New Brunswick, 26 May to 28 September, 1980. Arrows between sample dates denote permethrin treatments.

Table 15. Benthos diversity in five rock balls with one standard deviation, treatment, and control streams. York County, N.B., 27 May to 20 October 1980

Date	Control	1 x 17.5 g/ha	2 x 17.5 g/ha	1.4 km downstream	4.2 km downstream
27 May	2.5 ± 0.22	3.1 ± 0.09	3.0 ± 0.44	3.3 ± 0.20	3.2 ± 0.18
5 June	2.4 ± 0.46	2.8 ± 0.23	2.7 ± 0.32	2.8 ± 0.33	3.3 ± 0.15
10 June	2.5 ± 0.16	2.6 ± 0.36	2.4 ± 0.60	1.8 ± 0.27	3.1 ± 0.22
8 July	2.2 ± 0.18	2.1 ± 0.23	1.5 ± 0.44	1.5 ± 0.33	2.3 ± 0.46
19 August	2.8 ± 0.32	2.6 ± 0.58	2.2 ± 0.45	2.3 ± 0.33	2.7 ± 0.07
20 October	2.9 ± 0.27	3.0 ± 0.43	3.3 ± 0.07	NS	NS

NS - No samples taken.

Table 16. Benthos diversity in 4 Surber samples with one standard deviation, treatment, and control streams. York County, N.B., 25 May to 28 September 1980

1980	Control	1 x 17.5 g/ha	2 x 17.5 g/ha	1.4 km downstream	4.2 km downstream
25 May	2.6 ± 0.26	2.7 ± 0.37	3.0 ± 0.34	3.2 ± 0.20	2.6 ± 0.46
2 June	2.7 ± 0.27	2.1 ± 0.91	3.1 ± 0.26	2.8 ± 0.70	2.9 ± 0.55
6 June	2.7 ± 0.26	2.6 ± 0.26	2.9 ± 0.77	2.9 ± 0.32	2.9 ± 0.41
11 June	2.5 ± 0.48	2.5 ± 0.24	2.2 ± 0.45	2.7 ± 0.55	2.4 ± 0.83
17 June	2.7 ± 0.45	2.5 ± 0.39	2.5 ± 0.44	2.1 ± 0.50	2.3 ± 0.61
4 July	2.4 ± 0.55	1.9 ± 0.09	2.2 ± 0.61	1.4 ± 0.44	2.2 ± 0.25
13 August	2.0 ± 0.68	2.4 ± 0.51	2.2 ± 0.40	2.7 ± 0.22	1.5 ± 0.41
28 September	3.0 ± 0.27	3.0 ± 0.29	3.2 ± 0.35	3.1 ± 0.13	3.1 ± 0.23

samples to coincide with similar low numbers in the control, which reflected the normal decline in blackfly larvae in late spring and early summer due to emergence of adults.

The impact of the permethrin on benthos in McCallum Brook in the single application block was considerably less than that documented by Kingsbury and Kreutzweiser (1979, 1980a) and Kreutzweiser (1982) from previous single or initial applications at the same rate to cold-water streams. Despite a large increase in drifting organisms immediately after the application (Section V), a measurable reduction of benthic invertebrates other than blackfly larvae did not occur. The small impact may have been because of a relatively light deposit measured in the single application block (Section III) and the brief 6-h exposure of aquatic invertebrates to permethrin concentrations of only 0.23 µg permethrin/L or less (Section IV).

Effects of the permethrin treatment on benthos in the double application block were substantially greater. Benthic invertebrates, especially Plecoptera and Ephemeroptera, were reduced in Surber and rock ball samples after both applications. Reduction in numbers was accompanied by a decline in diversity, and although certain taxa (notably Baetidae and Simuliidae) were virtually eliminated, the lower diversity was largely the result of large increases of chironomid midge larvae by early July. Recovery of bottom fauna populations was evident by the end of September, but fall increases due to the appearance of the next generation were considerably less than those at the control and single application stations. Biomass was not measured directly but was probably reduced, based on the volume of fall samples. The decline in benthos numbers resulting from the double application was comparable with reductions documented by Kingsbury and Kreutzweiser (1979) after earlier experimental double applications of permethrin at 17.5 g/ha. They found that Ephemeroptera, Plecoptera, and Trichoptera were most affected, with total reductions of 80% and more. In all instances, the second applications further reduced benthos populations already reduced by the first application.

After the permethrin applications to the double application block, blackfly larvae virtually disappeared from quarry tiles. At this time, simuliid larvae on rocks taken at random from the stream bottom appeared limp and responded little or not at all to touch. Muirhead-Thomson (1977) reported 94% mortality of late-instar *Simulium* larvae in laboratory tests of 30-min exposures to 5 µg/L, and rapid irritant effects and detachment from the substrate at concentrations less than 5 µg/L. Muirhead-Thomson (1971) suggested that simuliid larvae are particularly susceptible to pesticides under field conditions because they are filter feeders. Elliot et al. (1978) reported that permethrin is strongly adsorbed to sediments and organic matter, and could thus be expected to adhere to the suspended particles that blackflies filter from stream water.

Effects on the bottom fauna 1.4 km downstream from the double application block were similar to those within the block. Benthic invertebrates at the downstream station declined after both applications and partially recovered by the end of September, although Ephemeroptera and Plecoptera did not attain the late-season high numbers reached at the single application and upstream control stations. The impact of permethrin on benthos at this station may not have resulted entirely from residual pesticide carried downstream from the spray blocks, because significant contamination through aerial drift was noted following the first application, and indicated after the second (by increased drift of benthos in an adjacent untreated stream). Kingsbury and Kreutzweiser (1980a) found concentrations toxic to aquatic invertebrates, especially early-instar Ephemeroptera and Plecoptera, 2 km downstream from a spray block treated with permethrin at 17.5 g/ha. They attributed this to downstream transport of permethrin from the treated area.

Disturbance of benthic organisms 4.2 km downstream from the double application block was much less but still apparent. Population reductions that did occur were more obvious after the second application, which coincided with greater deposit and higher residues in the double application block. The lesser effect is attributed to dissipation of insecticide over the 4.2 km of stream, and to dilution by a major tributary that almost doubled the stream flow just below the 1.4 km downstream station.

The experiment provided an opportunity to compare the utility and sensitivity of rock balls and Surber samplers. Rock balls have to be placed in the stream about 4 weeks before they are collected, whereas Surber samples require only one trip to the sample site. Samples from rock balls and Surber samples are not comparable because they sample different elements of the benthos. This difference is partly because Surbers were used in riffles and rock balls were generally placed in the tails of pools. Rock ball samples consistently produced more organisms per sample than did Surbers, with lower standard deviations from the means, partly because there were five replicates to four for Surbers.

Comparison of rock ball and Surber samples taken on five occasions from four stations, where samples were located close together and sampled about the same time, indicated that organisms were three times more numerous in rock balls. The greatest difference at the order level was with Plecoptera naiads which were eleven times more abundant in rock balls than in Surber samples. A large, distinctive stonefly, *Phasganophora capitata*. was completely absent in rock balls. Trichoptera were almost equally abundant in rock balls and Surber samples but representation by family was different. Families substantially more prominent in rock balls were Leptophlebiidae (Ephemeroptera) and Polycentropodidae (Trichoptera); substantially more prominent in Surber samples were Heptageniidae (Ephemeroptera) and Brachycentridae and Glossosomatidae (Trichoptera).

The two sampling techniques, despite differences in detail, produced similar results. This finding reinforces our confidence in stating that benthos numbers were substantially reduced as a result of the double application of permethrin at 17.5 g/ha as far as 1.4 km downstream, that the single application had little effect on benthos numbers, and that recovery of benthos numbers was essentially complete by late September. Late-season recovery was largely due to the appearance of small larvae of the next generation, but whether this recovery was due to regeneration within the depleted stretch or recolonization by downstream drift of organisms from untreated areas is not known. It was most likely due to a combination of both, depending on the propensity to drift of the various taxa. Diversity indices calculated from samples of both types gave results similar to those for numbers.

VII. FISH DIET STUDIES

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The effect of the permethrin treatments on the quantities and types of food consumed by resident fish populations within the Young's Brook watershed was studied by FPMI's Environmental Impact Section.

METHODS

Sampling sites for fish diet analysis were selected in the upstream control portion of Young's Brook and in sections near the middle of both the single and double application block. Indigenous populations of 1+ Atlantic salmon, 2+ Atlantic salmon, brook trout, and slimy sculpins in the three areas were sampled with the use of an electroshocker and dip net for measurement, sexing, and diet analysis. Total length, fork length, weight, and sex were determined for each of a sample of 10 fish using a measuring board, an Ohaus 1600 gram capacity balance, and dissecting tools. The stomach from each fish was extracted and preserved in 10% formalin to be opened later and analyzed for food content by microscopic examination and food volume by water displacement.

RESULTS

Diet compositions of Atlantic salmon, brook trout, and slimy sculpins are presented in Figures 12-21; Table 17 contains a list of abbreviations used for representing various food items in the groups. Actual fish sampling and stomach analysis results are listed in Appendices V and VI.

1+ salmon

Stomach contents of 1+ salmon in both the single and double application blocks were comprised largely of Ephemeroptera nymphs (71-78%) prior to the permethrin application (Figures 12 and 13). One to three days after the applications, the salmon continued to feed on a variety of aquatic insects but with a noticeable reduction in the number of ephemeropterans. By early July to mid-August a major portion of the food organisms selected by 1+ salmon (67-91% in the single and 34-42% in the double application block) consisted of Diptera larvae, especially Chironomidae and Athericidae. Stomach content analysis of salmon in both blocks in late September indicated a continued decrease in the percent contribution of ephemeropterans, but a substantial increase in the selection of Plecoptera nymphs and a major increase in the utilization of Trichoptera larvae. The percent contribution of terrestrial arthropods to the stomach contents of 1+ salmon never exceeded 19% in the single and 21% in the double application block.

One plus salmon in the upstream control were not present in numbers sufficient for sampling until early July. During the period from early July to mid-August the salmon fed largely on Diptera larvae (50-62%) as

Table 17. Abbreviations used to denote fish stomach contents in Figures 12 to 21

Misc. - miscellaneous aquatic insects (1%).

Eph - Ephemeroptera nymphs

Odon - Odonata nymphs

Ple - Plecoptera nymphs

Hem - aquatic Hemiptera

Tri - Trichoptera larvae

Col - aquatic Coleoptera

Ath - Athericidae larvae

Chir - Chironomidae larvae

Hel - Heleidae larvae

Emp - Empididae larvae

Sim - Simuliidae larvae

Tip - Tipulidae larvae

Ol - Oligochaeta

Nem - Nematoda

Hy - Hydracarina

Dec - Decapoda

Lim - Gastropoda (Limpets)

TA - terrestrial arthropods

egg - fish eggs

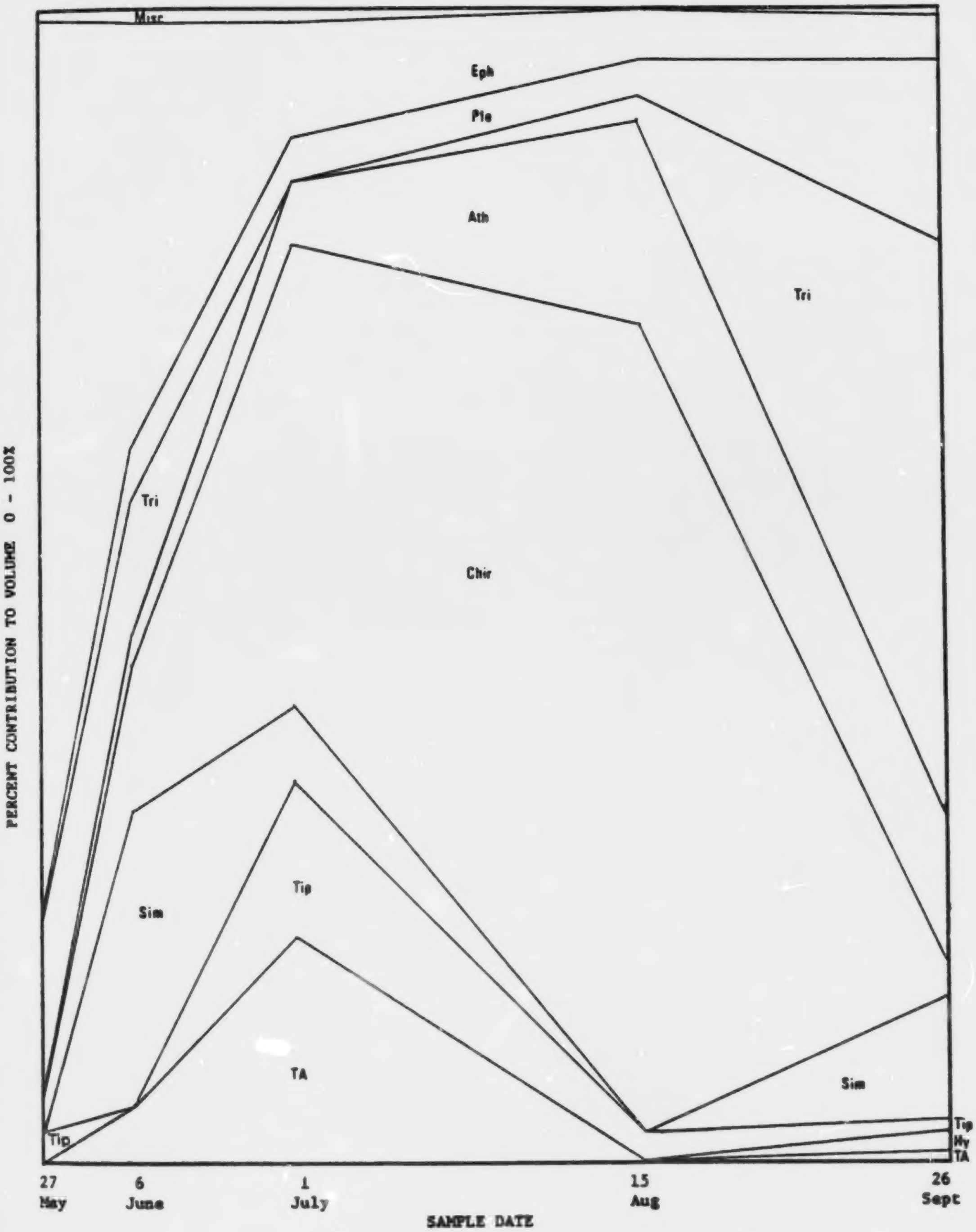


Figure 12. Contribution of various food organisms to stomach contents of 1+ Atlantic salmon in single application block, McCallum Brook, York County, N.B., treated with 17.5 g AI/ha permethrin on 3 June 1980.

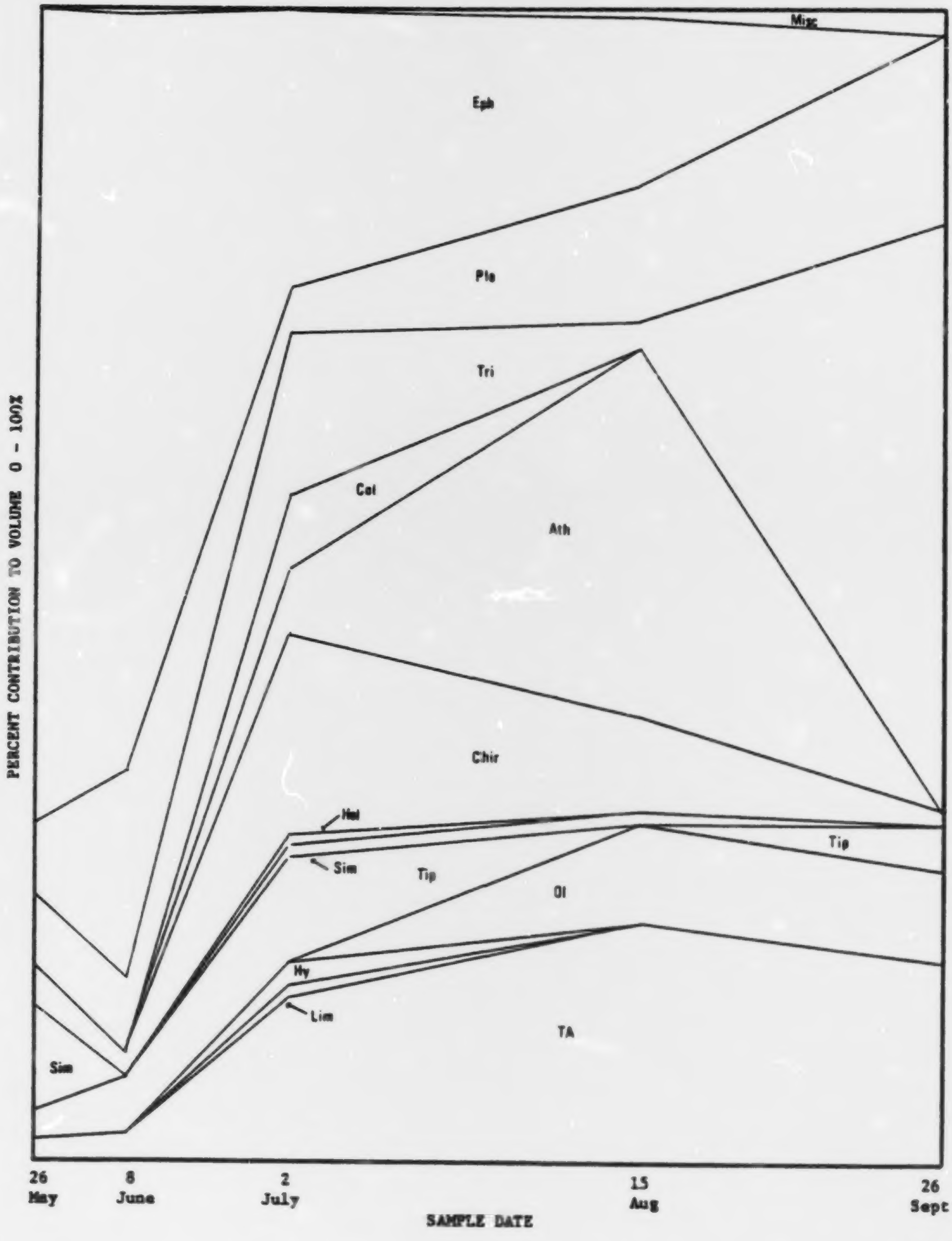


Figure 13. Contribution of various food organisms to stomach contents of 1+ Atlantic salmon in double application block, Young's Brook, York County, N.B., treated with 17.5 g AI/ha permethrin on 3 and 7 June 1980.

well as Trichoptera larvae, Plecoptera nymphs, and a limited number of Ephemeroptera nymphs (Fig. 14). By the end of the sampling period Trichoptera larvae comprised the largest proportion of stomach contents (48%), followed by Plecoptera nymphs, various Diptera larvae, and Ephemeroptera nymphs. Terrestrial arthropods contributed 0-18% of the volumes of stomach contents during the sampling period.

2+ salmon

Prespray diet of 2+ salmon in the single application block resembled that of the 1+ salmon, with a predominance of Ephemeroptera nymphs and a lesser representation of a variety of aquatic insects. Stomach content samples taken three days after the application indicated a substantial decrease of ephemeropterans coupled with increases in Plecoptera and Simuliidae (Fig. 15). By the first of July to mid-August the 2+ salmon were feeding mainly on Diptera larvae (40-46%) and terrestrial arthropods (39-40%); in late September the stomach contents consisted almost entirely of trichopterans (84%). Feeding activity of 2+ salmon in the double application block followed a similar pattern but with a noticeably greater (up to 76%) utilization of terrestrial arthropods by mid to late summer (Fig. 16).

The trend toward a decreasing selection of Ephemeroptera nymphs was also evident in 2+ salmon in the control area, but to a lesser extent than that demonstrated in the single or double application blocks. Diptera larvae and trichopterans comprised the major portion of the stomach contents with 11-66% and 16-71% contribution respectively. A substantial increase in trichopterans at the end of the season parallelled a similar occurrence in both application blocks. The percent contribution of terrestrial arthropods to the diets of 2+ salmon in the control stream did not exceed 17% (Fig. 17).

Brook Trout

The percent contribution of aquatic insects to the stomach contents of brook trout in the single application block steadily declined from a prespray level of 91%-23% in mid-August with an alternate utilization of terrestrial arthropods (Fig. 18). In late September the diet of brook trout was almost entirely comprised of ephemeropterans (25%), trichopterans (30%) and terrestrial arthropods (44%). Brook trout in the double application block continued to feed largely on a variety of aquatic insects one day following the second application, with a substantial increase in the selection of Plecoptera nymphs (Fig. 19). By 25 days after the applications, plecopterans had disappeared from the diet of brook trout, and numbers of ephemeropterans and trichopterans had greatly decreased. Coleopterans, chironomids, and terrestrial arthropods increased to collectively make up 89% of the total contribution of food organisms. The number of brook trout in the sampling area of the double application block appeared to be drastically reduced during this period. Intensive sampling on 2 and 3 July resulted in the collection of only two brook trout, and no trout

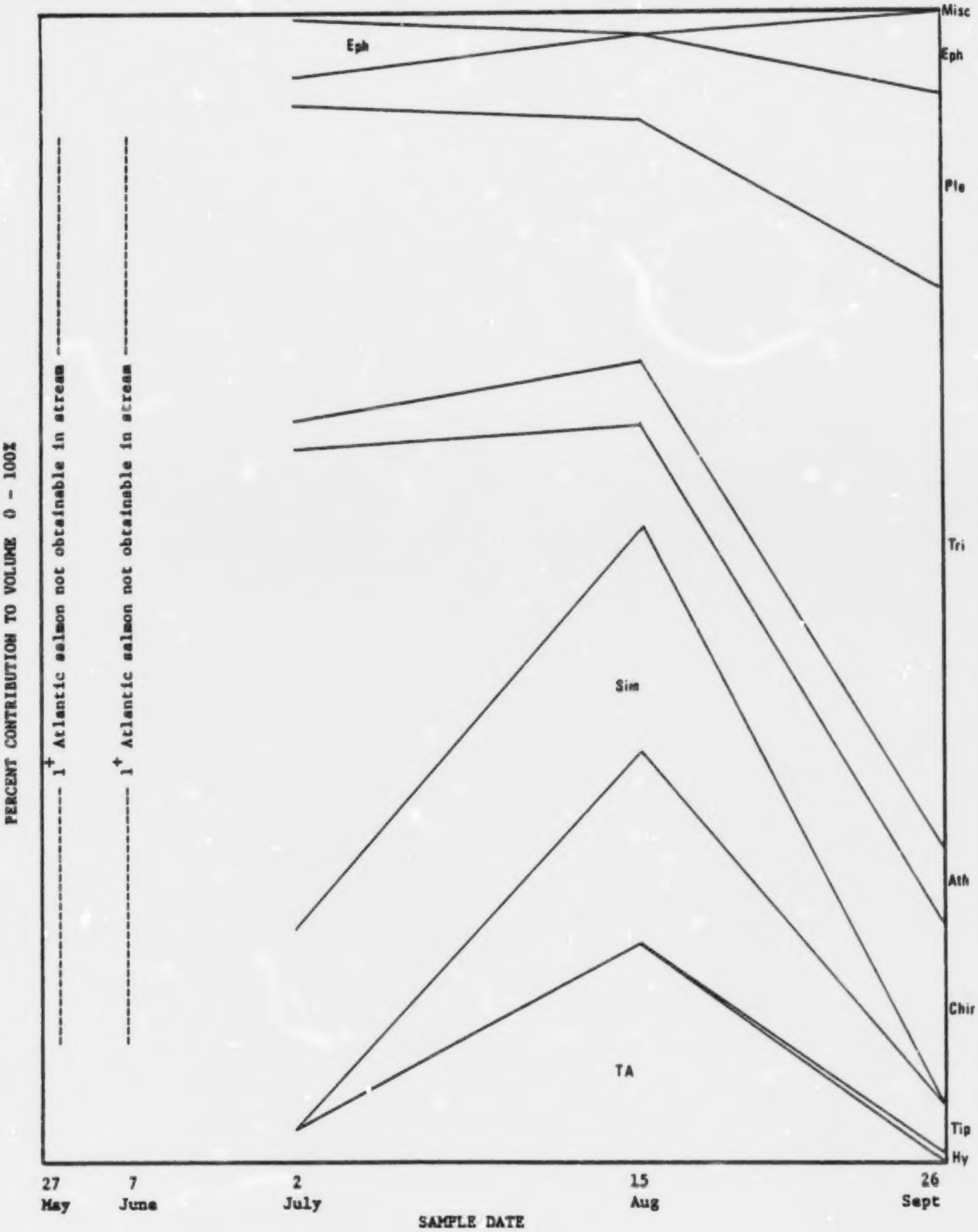


Figure 14. Contribution of various food organisms to stomach contents of 1+ Atlantic salmon in untreated control section of Young's Brook, York County, N.B., 1980.

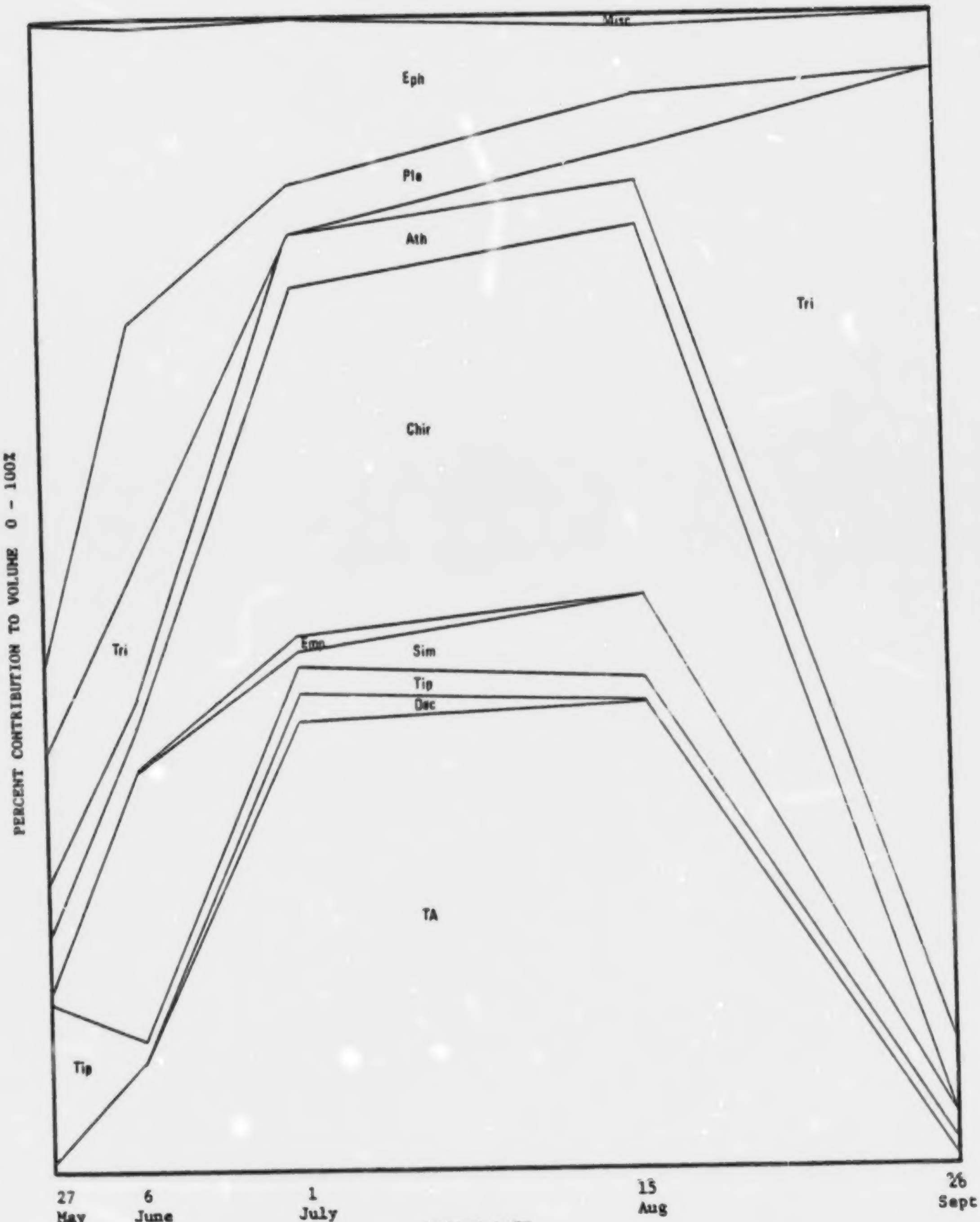


Figure 15. Contributions of various food organisms to stomach contents of 2+ Atlantic salmon in single application block, McCallum Brook, York County, N.B., treated with 17.5 g AI/ha permethrin on 3 June 1980.

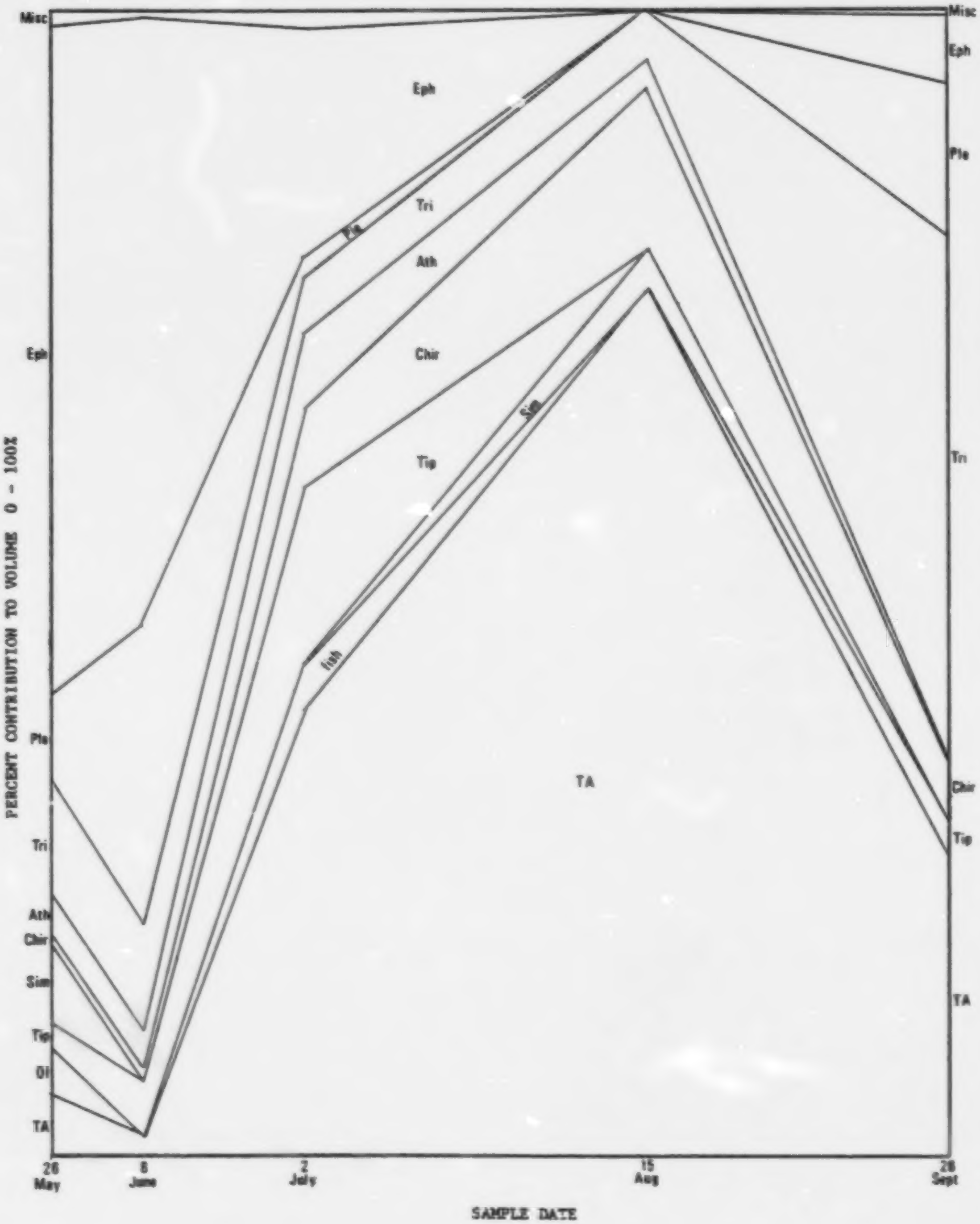


Figure 16. Contribution of various food organisms to stomach contents of 2+ Atlantic salmon in double applicaiton block, Young's Brook, York county, N.B., treated with 17.5 g AI/ha permethrin on 3 and 7 June 1980.

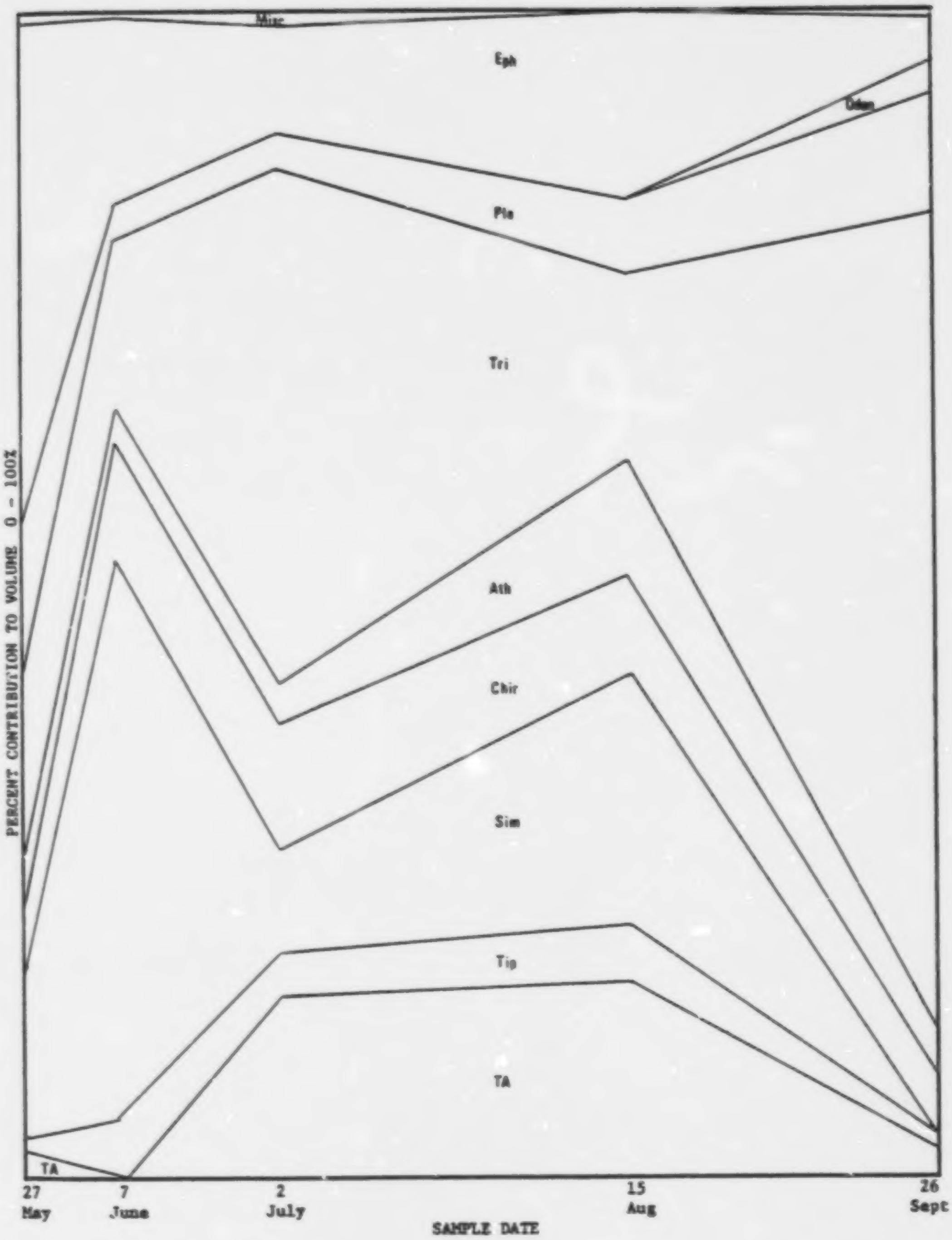


Figure 17. Contribution of various food organisms to stomach contents of 2+ Atlantic salmon in untreated control section of Young's Brook, York County, N.B., 1980.

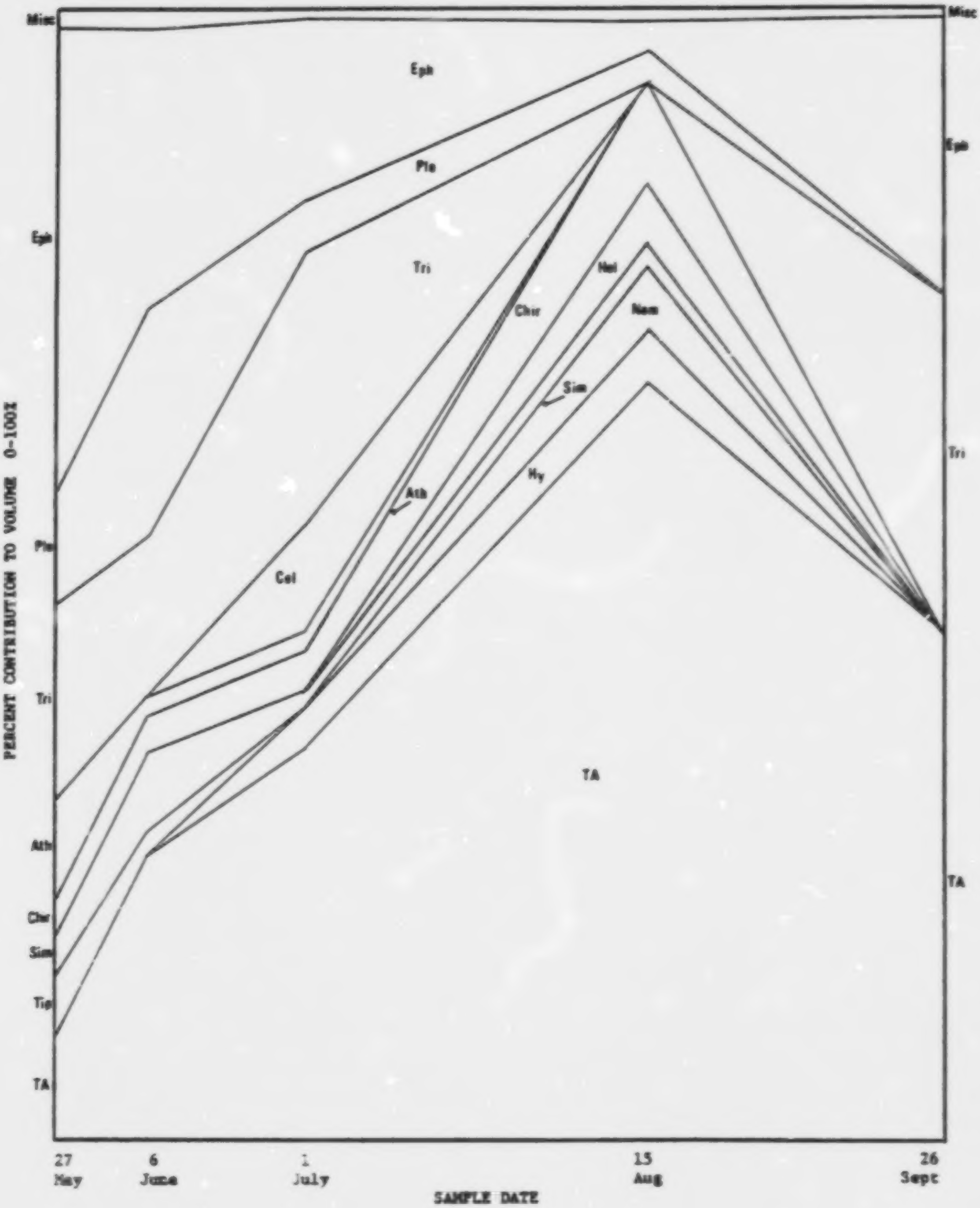


Figure 18. Contribution of various food organisms to stomach contents of brook trout in single applicaton block, McCallum Brook, York County, N.B., treated with 17.5 g AI/ha permethrin on 3 June 1980.

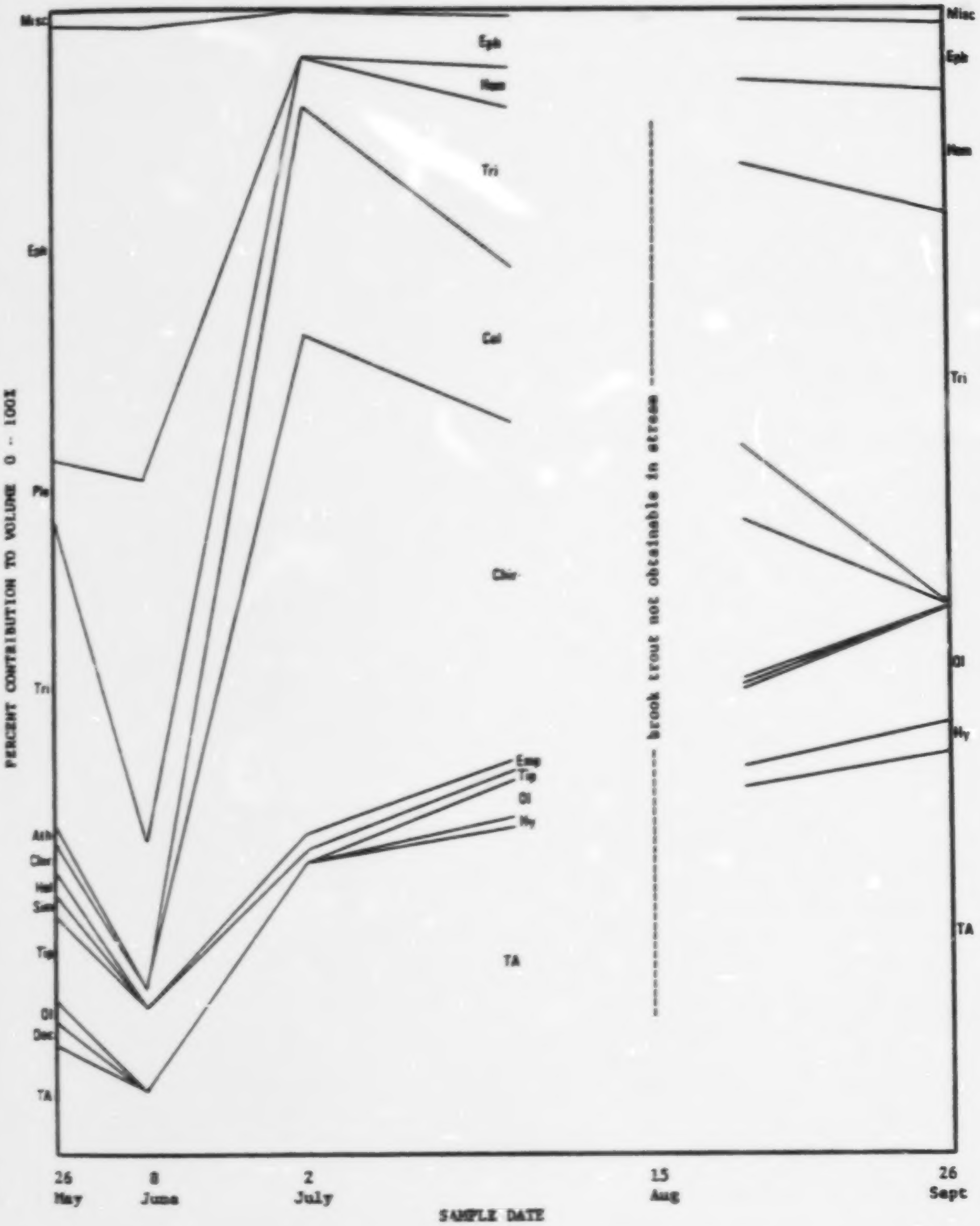


Figure 19. Contribution of various food organisms to stomach contents of brook trout in double appliation block, Young's Brook, York County, N.B., treated with 17.5 g AI/ha permethrin on 3 and 7 June 1980.

were obtained on the 15 August sampling date. By the end of the season, stomach contents of a sample of 10 brook trout indicated a diet consisting largely of terrestrial arthropods (35%), trichopterans (34%), oligochaetes (11%), and aquatic hemipterans (11%).

Brook trout in the upstream control shifted from a virtually complete dependence on a variety of aquatic insects prior to and during the application dates, to an increased selection of terrestrial arthropods (41-65%) from early July to the end of the season) (Fig. 20). Ephemeropterans and Diptera larvae decreased in percent contribution to stomach contents; the selection of plecopterans remained relatively consistent throughout the sampling period. Trichopterans comprised a significant portion of the food organisms selected during the early and mid-season sampling (10-22%) and increased to 34% by the end of September.

Slimy sculpins

Prior to the permethrin applications, sculpins in both the single and double application blocks fed primarily on Ephemeroptera nymphs and Simuliidae larvae (Fig. 21). Stomach analyses 1-3 days after the applications indicated heavy feeding on ephemeropterans, a virtual elimination of simuliids, and a slight increase of other aquatic insects. By early July ephemeropterans had been substantially reduced, but in conjunction with Diptera larvae continued to contribute a major portion of the food organisms selected for the remainder of the season. In the application blocks, both plecopterans and trichopterans demonstrated moderate increases in the stomach contents of slimy sculpins at the end of the season.

The diet composition of sculpins at the control site resembled that of the sculpins in the two application blocks, but with a lesser dependence on ephemeropterans prior to or at the time of the applications in the treatment blocks. Stomach contents of the sculpins consisted mainly of Diptera larvae and ephemeropterans, with a large increase in the percent contribution of trichopterans at the end of the season. Terrestrial arthropods comprised a larger portion of the diets of sculpins in the control than those in the treatment blocks, but never exceeded 12%.

Volume of food consumed

The volume of food organisms consumed by Atlantic salmon increased approximately twofold immediately following the application dates, then subsequently declined until mid-August in both treatment and control areas (Table 18). The volume of food uptake by the salmon increased slightly in all but one instance (2+ salmon in the single application block) on the 26 September sampling date.

One to three days following the permethrin treatments, the volumes of stomach contents of brook trout in the single and double application blocks increased by 6.5 and 1.9 times, respectively (Table 18). This was followed by a sharp decline to a level in early July substantially lower

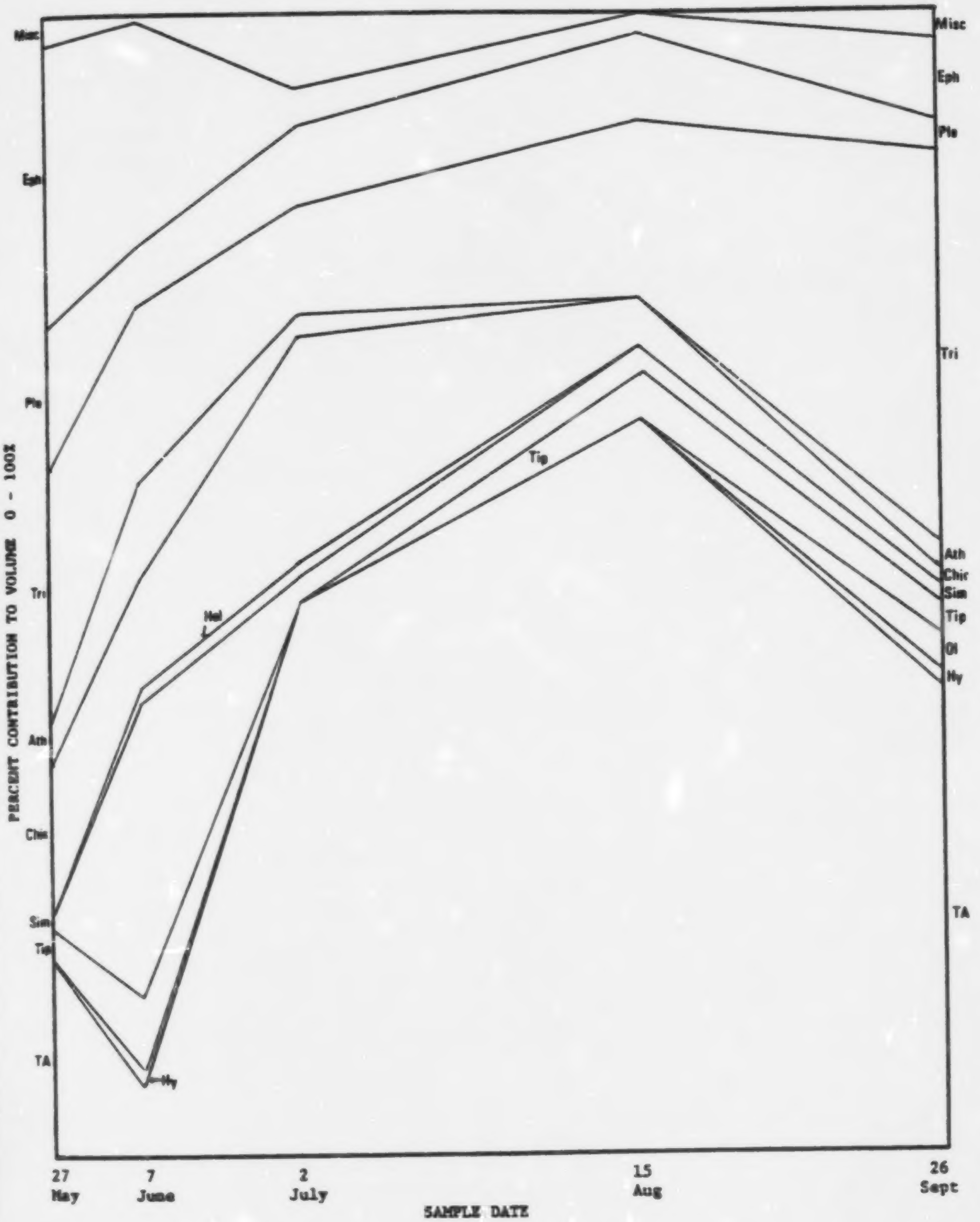


Figure 20. Contribution of various food organisms to stomach contents of brook trout in untreated control section of Young's Brook, York County, N.B., 1980.

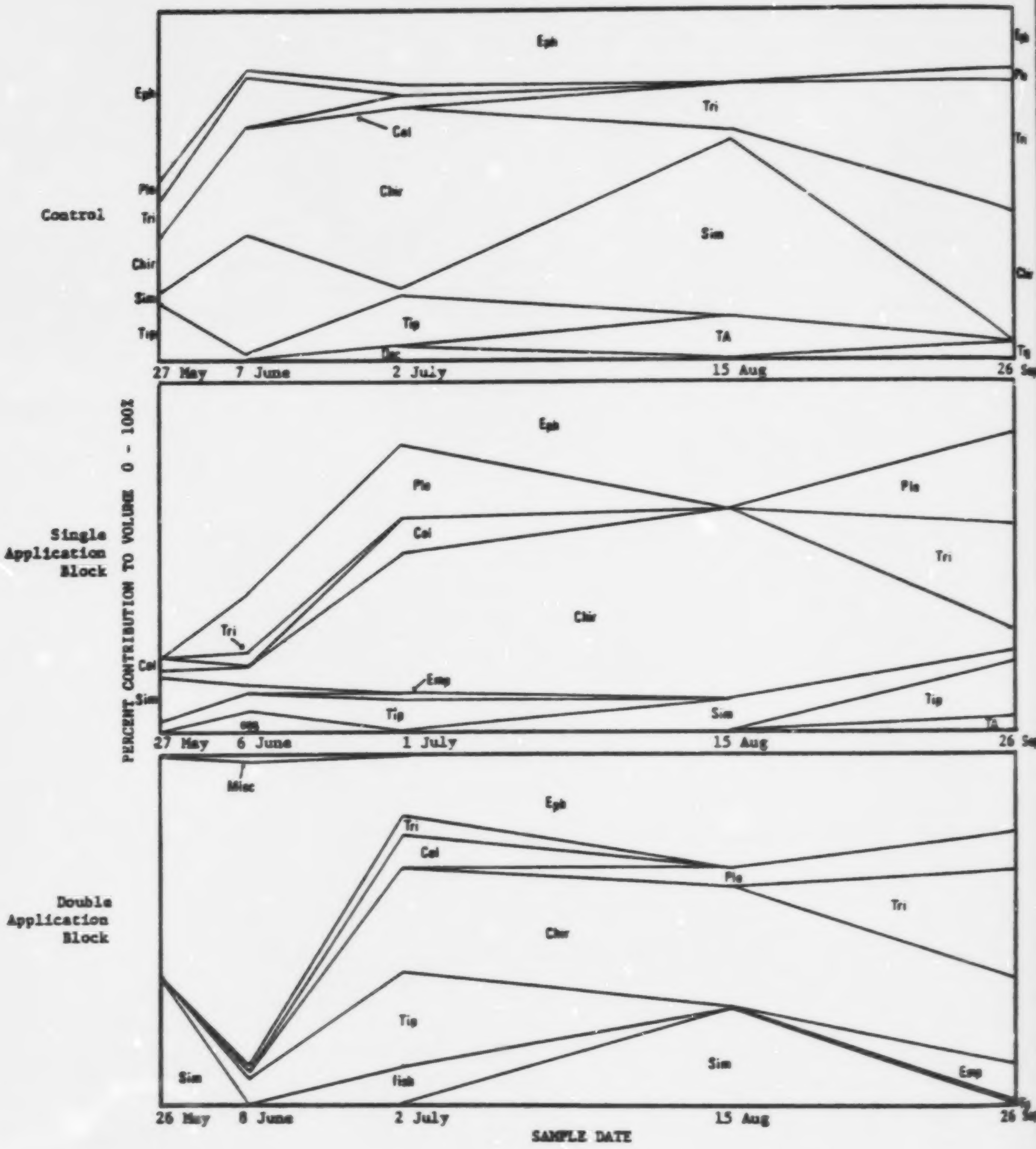


Figure 21. Contribution of various food organisms to stomach contents of slimy sculpins in untreated control section of Young's Brook, in double application block on Young's Brook treated with 17.5 g AI/ha permethrin on 3 and 7 June 1980, and in single application block on McCallum Brook treated with 17.5 g AI/ha permethrin on 3 June 1980.

Table 18. Relative values expressing volumes of food organisms* consumed by indigenous fish species in treatment and control areas, York County, N.B., 1980.

	26-27 May	6-8 June	1-2 July	15 Aug.	26 Sept.
Control					
1+ salmon	-	-	1.42	0.46	0.66
2+ salmon	2.93	4.07	2.80	1.96	1.97
brook trout	4.73	4.31	3.15	2.78	3.81
slimy sculpins	0.73	1.70	0.85	0.65	0.84
Single application block					
1+ salmon	1.22	1.64	1.20	0.79	0.85
2+ salmon	2.29	6.53	1.03	0.74	0.70
brook trout	5.40	35.12	2.04	3.48	1.20
slimy sculpins	0.44	1.58	1.10	0.59	0.42
Double application block					
1+ salmon	1.09	2.16	1.36	1.23	1.39
2+ salmon	4.37	7.36	3.00	0.39	2.75
brook trout	12.14	23.20	1.93	N.A.	8.22
slimy sculpins	0.44	3.32	0.91	1.01	0.27

* Calculated as:

$$\frac{\text{mean volume stomach contents (ml)}}{\text{mean fork length (mm)}} \quad \times 10^3$$

than the prespray volumes of food organisms consumed. By the end of September, the volumes of food consumed by brook trout in the single application block attained a seasonal low, while those of brook trout in the double application block increased to a level approaching that of the prespray feeding activity. The volumes of stomach contents of brook trout in the control stream declined steadily from the initial sampling date to mid-August, then increased slightly at the end of the season (Table 18).

The volume of food consumed by slimy sculpins immediately following the permethrin applications increased by 3.6 times in the single and 7.5 times in the double application block, but resembled an increase of 2.4 times in the control stream during the same period. In both treatment blocks the food consumption by sculpins attained a seasonal low by the end of September, while the volume of food organisms consumed by sculpins in the control returned to a level slightly higher than the prespray average.

DISCUSSION

Juvenile Atlantic salmon in both the single and double application blocks demonstrated a seasonal feeding activity pattern with a shift from an initial heavy reliance on Ephemeroptera larvae, followed by a mid to late summer dependence on various Diptera larvae and to a certain extent terrestrial arthropods, to a predominant selection of Trichoptera by the end of September. This pattern was very similar to the feeding activity of juvenile salmon in the upstream control, except that the early-season decrease in utilization of Ephemeroptera larvae was noticeably more pronounced in both application blocks after the permethrin treatments than in the control during the same period. This reflects the documented reductions in Ephemeroptera populations that were evident, especially in the double block, following the applications (Section VI).

Slight postspray increases in the variety and volume of food organisms in stomachs of juvenile salmon indicate a certain degree of opportunistic feeding on pesticide-affected invertebrates either drifting or less capable of avoiding predation. Following the initial postspray increases, the volume of food organisms consumed by the salmon in both treated and control areas declined to a seasonal low in mid-August and then increased slightly by the end of September. Benson (1953) and Thomas (1962) reported similar feeding patterns with the volume of contents of salmonid stomachs being the greatest in spring and early summer. Stomach content analysis of juvenile salmon showed little difference in the food organism selection of yearling and 2+ salmon, except that the older fish in both treatment blocks relied more heavily on terrestrial arthropods than did 1+ salmon in all three areas or 2+ salmon in the control. Although Scott and Crossman (1973) infer that an increased proportion of terrestrial arthropods in the diets of Atlantic salmon parr during mid to late summer may be normal, the comparatively greater reliance on terrestrial insects by 2+ salmon in both treatment streams may suggest that an alternate food source was being pursued as benthic organisms became more difficult to obtain after the applications.

Brook trout in both treatment streams showed greater postspray opportunistic feeding on pesticide-affected invertebrates than that demonstrated by salmon parr in the same areas. Since the permethrin applications resulted in short-lived but dramatic increases in the number of drifting invertebrates, the availability of food organisms in the drift was substantially increased after each treatment. Keenleyside (1962) observed that young brook trout fed on drifting invertebrates much more frequently than salmon parr, and Elliott (1970) reported that the feeding activity of brown trout *(Salmo trutta* L.) increased proportionally to the availability of benthic invertebrates in the drift. The immediate postspray opportunistic feeding of brook trout in permethrin-treated streams has been previously documented by Kingsbury and Kreutzweiser (1980b).

The shift from largely aquatic to predominantly terrestrial invertebrates in the diet of brook trout from the single application block in mid to late summer may not have been pesticide impact related because a similar change in diet was found in brook trout at the control. Allan (1981), Ricker (1930), Needham (1930), Wurtsbaugh et al. (1975) and Kingsbury and Kreutzweiser (1979, 1980b) have documented comparable patterns of feeding activity with an increased selection of terrestrial arthropods by brook trout from untreated cold water streams in mid to late summer. The utilization of terrestrial insects by brook trout in the present study was noticeably greater than that demonstrated by juvenile Atlantic salmon in the three study areas and reflects basic differences in feeding behavior. Whereas salmon parr generally inhabit fast-flowing riffle areas and usually maintain a fairly stationary position in contact with or close to the substrate (Keenleyside 1962; Gibson 1973) young brook trout tend to frequent somewhat slower water and actively feed at various depths, and are consequently more likely to encounter and ingest drifting terrestrial organisms.

Despite easily attained and apparently large numbers of brook trout in the double block prior to and immediately following the applications, extensive electroshocking in this section of stream in early July resulted in the collection of only two brook trout; no trout were obtained on the 15 August sampling date. This reduction in numbers may be at least partly due to brook trout, in competition with indigenous Atlantic salmon parr for a depleted food resource (demonstrated by reductions of organisms in benthos samples), being forced to emigrate from the area in search of more readily available food. In a study of juvenile brook trout and Atlantic salmon coexisting in an untreated coldwater stream, Gibson (1973) found evidence that the brook trout were displaced by salmon when food became less available, probably as a result of the more aggressive behavior of the salmon. The author states that "as food becomes scarce, the two species tend to move into separate habitats, aggravated probably by the greater aggression of salmon parr when starved". Symons (1971) concurs with his reported observations that juvenile Atlantic salmon, when subjected to a period of low food availability, showed an increase in aggressive behavior and drove away subordinate fish. During an experimental introduction of fenitrothion in a New Brunswick stream, Symons and Harding (1974) demonstrated that the impact of the pesticide dripped into the stream caused the emigration of some fish species, and consequently a decline in biomass, although results from concomitant monitoring studies of operational fenitrothion applications were less definitive. Brook trout in the single application block of the present study were reduced to a much lesser extent, but a decline in abundance was indicated in that extensive sampling in mid-August produced only a partial sample. Samples of brook trout from the untreated control area remained readily attainable throughout the entire season.

Subsequent sampling on 26 September in both application blocks indicated the presence of large numbers of salmon parr, and an apparent return of brook trout. All fish were easily collected and contained a variety of food organisms similar to the composition of benthos samples collected during the same period, with a predominance of Trichoptera larvae.

Stomach content analysis of indigenous slimy sculpins did not demonstrate adverse effects of the permethrin applications on the feeding activity of this species. Substantial increases in the volume of food consumed were found immediately after the applications in both the single and double blocks, but a similar occurrence in the control area precludes definite indications of opportunistic feeding on pesticide-affected organisms. Although Kingsbury and Kreutzweiser (1979, 1980b) have documented a shift in sculpin diets to almost exclusively Chironomidae larvae following permethrin applications, this pattern was not evident in the present study and sculpins continued to utilize a selection of aquatic invertebrates similar to that consumed by sculpins in the control.

VIII. POSTSPRAY OBSERVATIONS ON FISH AND AQUATIC INVERTEBRATES

P. Kingsbury
Forest Pest Management Institute

Using a diving mask, visual observations were made within a several hundred meter stretch of Young's Brook at the downstream end of the double application block about 54 h after the first permethrin application. About twenty trout and salmon of various sizes were seen, all normal in appearance and behavior; many had noticeably distended stomachs due to gorging on distressed insects. About twelve white suckers, *Catostomus commersoni* (Lacepede), two blacknose dace, *Rhinichthys atratulus* (Hermann), and one crayfish were also observed, apparently unaffected by the treatment.

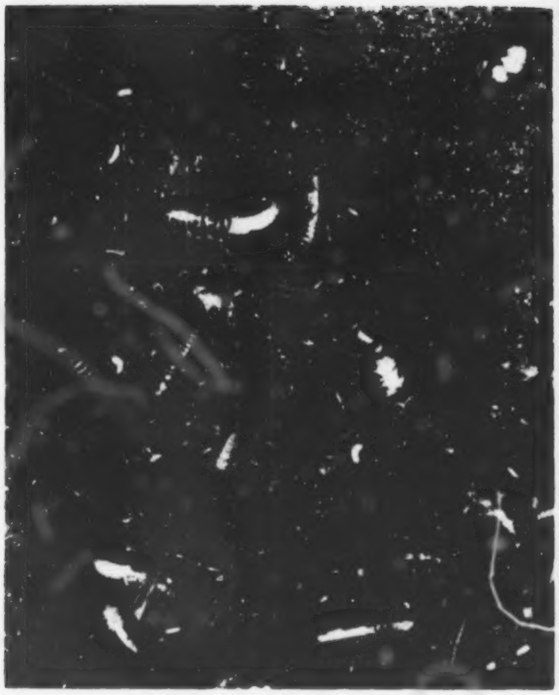
Although no dead fish or crayfish were found, large numbers of aquatic insects were observed lying on the stream bed behind rocks and in deep, slow areas (Fig. 22). Most were plecoptera and trichoptera; relatively few were ephemeroptera. Many of these insects were dead and many of the caddisfly larvae had crawled out of their cases, which Symons and Metcalfe (1978) found to be a sign of fatal distress in *Brachycentrus numerosus*. Other individuals were observed in various states of activity ranging from sporadic twitching while lying on their backs to normal orientation to the bottom and crawling movements. Indications of apparent recovery were particularly noticeable among the large numbers of stonefly nymphs, *Phasganophora capitata*. which were present in piles estimated at over a hundred individuals in pockets of slow water. Many were molting or had just completed molting as was indicated by their pure white coloration (Fig. 23). When transported back to the laboratory, newly molted nymphs began to take on the markings and coloration characteristic of this species within a matter of hours.

DISCUSSION

Visual observations confirmed the massive extent of permethrin-induced disturbances to aquatic insects evident from drift sampling (Section V). Some differences in the ability of different types of insects to recover from poisoning were suggested by the limited observations made, with larger insects seeming to be more resilient to poisoning than smaller ones. No visible signs or symptoms of pesticide effects on fish were apparent.

A possible explanation for the apparent high degree of synchrony in molting of large numbers of *Phasganopohora capitata* observed is that twitching movements resulting from subacute poisoning-initiated ecydsis. This would only be possible if a proportion of the population were in the so-called pharate phase (Hinton, 1946), when the new insect cuticle is fully formed and separated from the old cuticle, but the insect is still enclosed in the old cuticle (i.e., ecdysis has not occurred). In some insect populations this old cuticle may be retained for some time (Chapman, 1969) and twitching due to insecticide poisoning might result in spontaneous molting of the individuals in the pharate phase.

Fig. 22. Aquatic insects on the bottom of Young's Brook at the downstream end of the double application block 54 h after the initial permethrin application. Note the *Phasganophora capitata* nymph in the process of ecdysis.



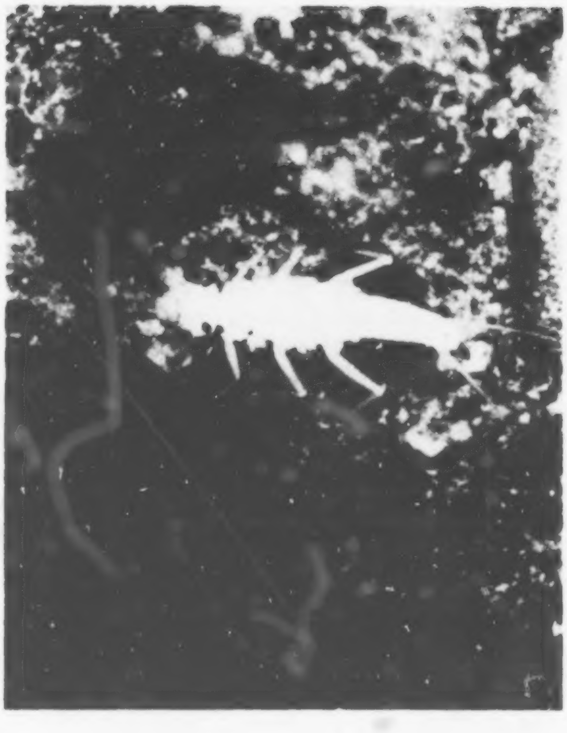


Fig. 23. Newly molted *Phasganophora capitata* present at the downstream end of the double application block 54 h after the first permethrin treatment.

IX. CAGED FISH AND CRAYISH STUDIES

A. Sosiak
Montreal Engineering Company Limited

Studies on the effects of single and double applications of permethrin at 17.5 g/ha on caged Atlantic salmon and crayfish were conducted by Montreal Engineering Company, Limited (MECO) under contract to FPMI. The experimental design, setup and project supervision were carried out by A. Sosiak of MECO, and FPMI field staff made the majority of the daily observations on the caged organisms.

METHODS

The main emphasis of the caged fish program was placed on studies of underyearling salmon because salmon fry have been found to be more susceptible to certain pesticides than parr (Elson 1967; Wildish et al. 1971), and because salmon fry could be conveniently obtained in larger numbers from a hatchery. Groups of fry were placed in upwelling boxes at two locations in each of the two spray blocks and at two unsprayed sites, and regularly observed for more than two weeks after spraying. A group of 1+ salmon were also caged at one site in the double application block and at an unsprayed site, and periodically observed. Freshwater crayfish (probably *Cambarus bartoni)* were placed in cages at five of the six sites where salmon fry were studied to assess their response to field exposure to permethrin. Both crayfish and their saltwater relative, the American lobster, have been shown to be quite sensitive in laboratory bioassays (Jolly et al. 1978; Zitko et al. (1979).

The location and numbering of caged fish and crayfish study sites are presented in Fig. 24. Water temperatures and pHs recorded at the sites over the study period are presented in Appendix VII.

Underyearling (0+) salmon were placed in upwelling boxes similar in principle to the incubators used in many salmon hatcheries. Water entered the lower of two chambers and upwelled through the upper chamber, which contained the newly hatched salmon fry, and then exited through the rear wall of the chamber. This design prevented direct exposure of the fry to the current, with which they were not yet able to cope. The upwelling boxes were of unfinished 1.8-cm thick wood, with 602 μ nylon screen separating the two chambers (Fig 25) and forming the rear wall of the upper chamber. A transparent plexiglass sheet, fit into grooves in the wood, covered the top of the upper chamber (which measured 30 x 30 x 10 cm) and was held in place by a retaining screw. The lower chamber (30 x 30 x 12.5 cm) was open at two opposite ends to permit water to flow through the chamber and up through the upper chamber. Upwelling boxes were placed on the stream bottom, near shore, generally to the level of the plexiglass top (Fig. 26), with the screen-covered side of the fish chamber facing downstream. The lower chamber

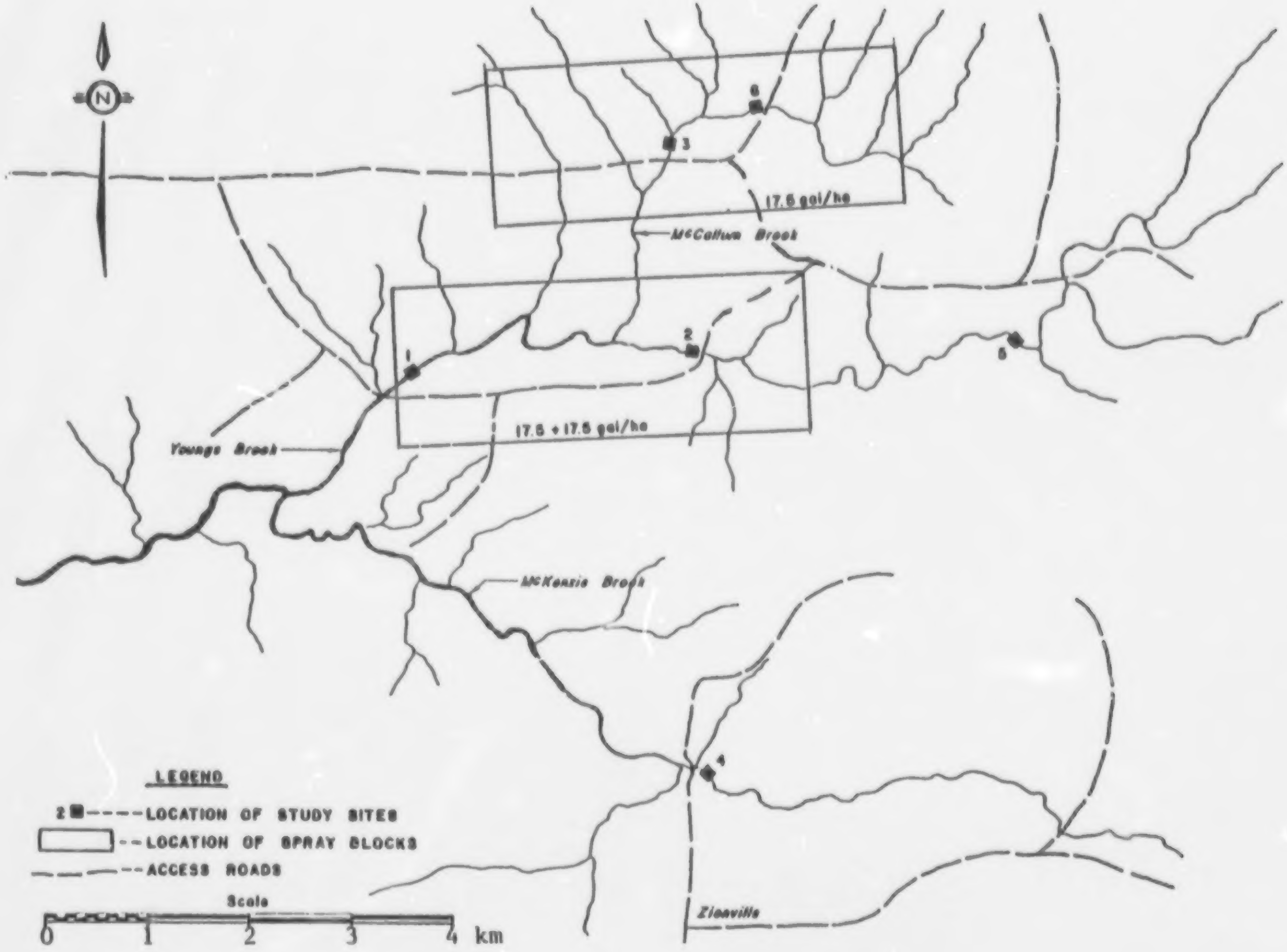
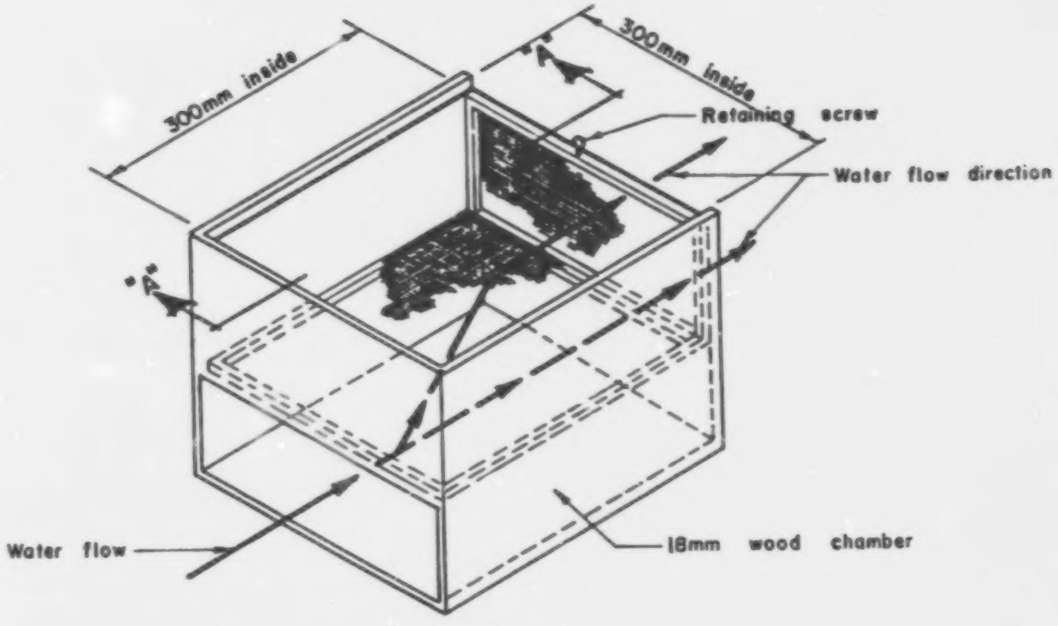
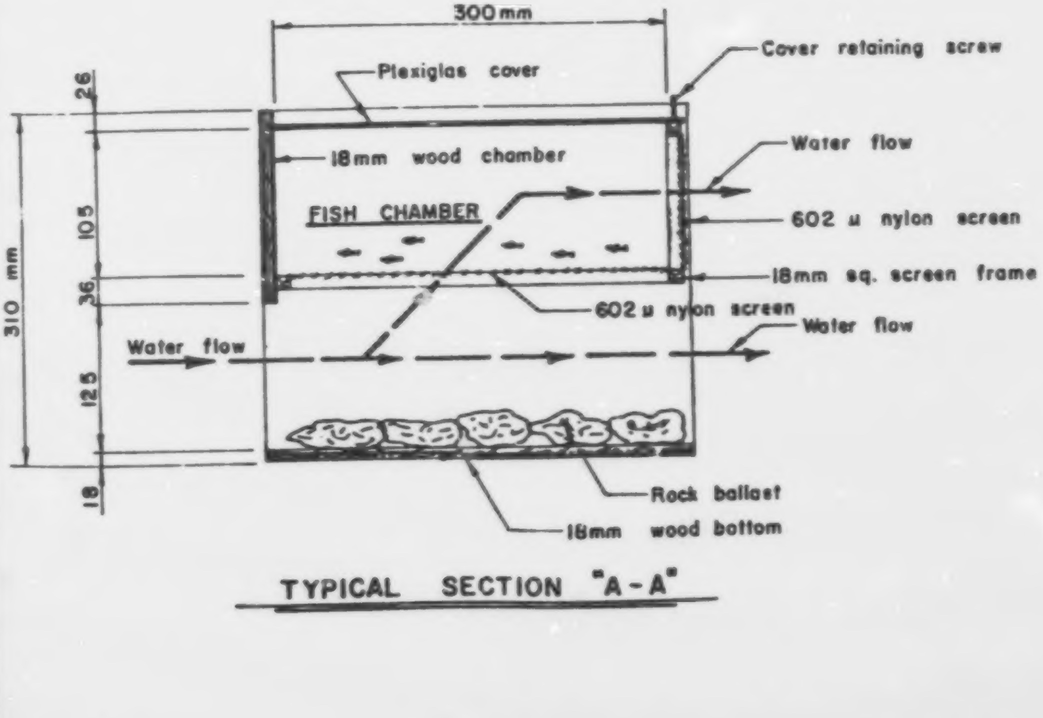

N
17.5 gal/ha
3
6
McCallum Brook
1
2
5
17.5 + 17.5 gal/ha
Youngs Brook
McKenzie Brook
4
Zionville
LEGEND
2 ---- LOCATION OF STUDY SITES
-- LOCATION OF SPRAY BLOCKS
--- ACCESS ROADS
Scale
0
1
2
3
4 km

Figure 24. Location of caged fish and crayfish and fish population study sites, Young's Brook watershed, New Brunswick 1980.


300mm inside
300mm inside
"A"
"A"
Retaining screw
Water flow direction
Water flow
18mm wood chamber

ISOMETRIC OF UPWELLING BOX


300mm
Cover retaining screw
Plexiglas cover
26
18mm wood chamber
Water flow
FISH CHAMBER
105
602 μ nylon screen
310 mm
36
18mm sq. screen frame
602 μ nylon screen
Water flow
Water flow
125
Rock ballast
18
18mm wood bottom

TYPICAL SECTION "A - A"

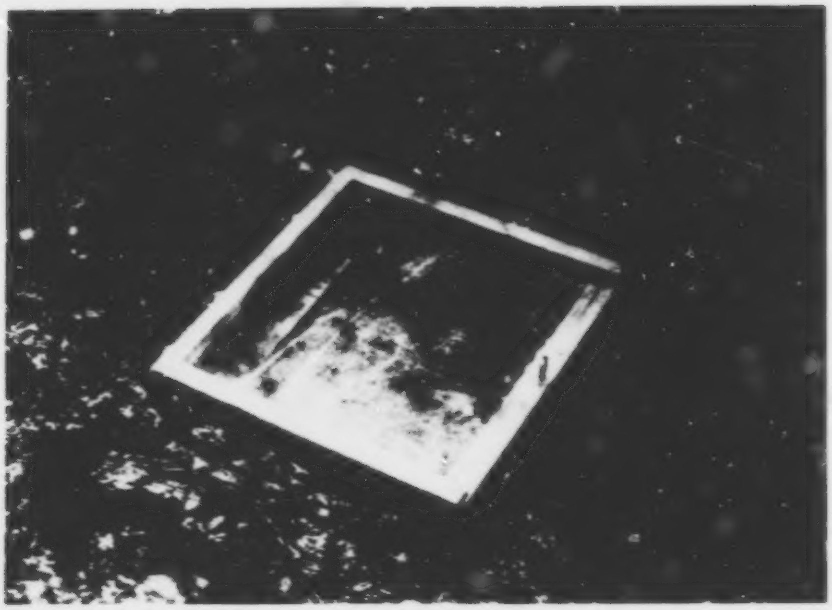


Fig. 26. Upwelling box containing 0+ salmon set in Young's Brook.

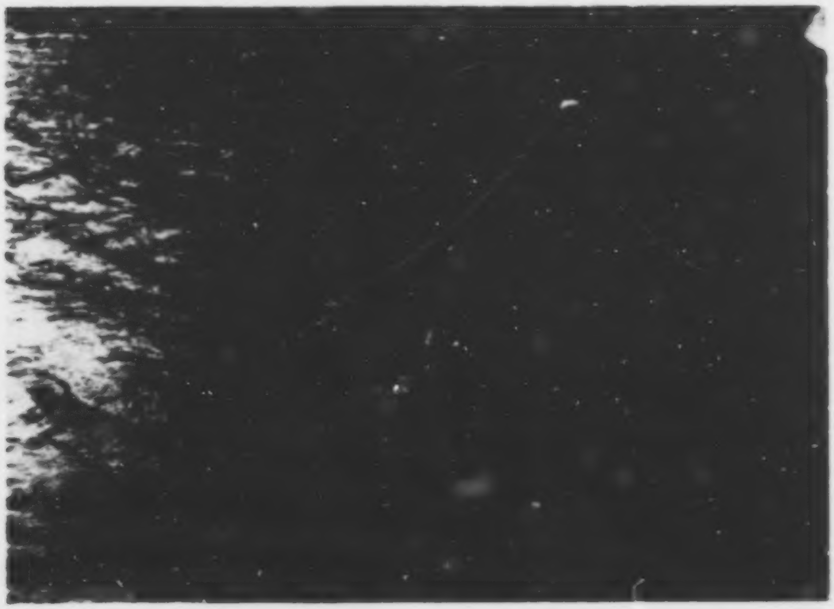


Fig. 27. Upwelling box covered with stones and tied to the shore set in the double application block in Young's Brook.

was filled with rocks for ballast and several flat rocks were placed on the plexiglass (Fig. 27). About 50 0+ salmon were placed in each of the two upwelling boxes at each site.

Underyearling salmon in the last stages of yolk-sac absorption were obtained on 28 May from the South Esk Fish Culture Station near Newcastle, N.B. They were the offspring of Miramichi River salmon and had been certified disease-free by the fish pathology laboratory operated by the Department of Fisheries and Oceans at Halifax, N.S., prior to transport. Hatchery personnel anticipated that first-feeding would occur the following week, as is usual for the South Esk Fish Culture Station. Some exhibited the heightened activity levels in hatchery troughs usually associated with swim-up.

All 0+ salmon were transferred to the study area in a large metal transport container (approximately 60 x 60 cm with 45 cm water depth). Driving time was about two hours to the first site, and approximately 100 were distributed to two upwelling boxes at Sites 3, 6, 5, 1 and 2 (Fig. 20) in that order, on the afternoon of 28 May. Fish were placed at Site 4 the following day, after spending the night in a cage at Site 2.

During the next two days, there was some mortality due to handling at Sites 1, 2 and 4. Most of the dead fish had obvious signs of abrasion injury, especially torn yolk-sacs. Dead fish were replaced at each site on 30 May. Upwelling boxes at Sites 1 and 4 were tampered with, possibly by curious fishermen, but no clearly related mortality occurred at those sites. Subsamples of 0+ salmon were measured 19 June, after completion of the study. Salmon at each site were observed daily before and after spray application (3 and 7 June) until 12 June. Thereafter they were observed every other day until 19 June when the study was terminated. Observations followed those proposed by Muirhead-Thomson (1971) for pesticide studies, observing mortality rate, activity level, respiration rate and manner, skin color, and response to stimulus. Except for mortality rate, observations were generally qualitative rather than quantitative.

Forty 1+ salmon parr were collected using a Smith Root D-C Model VI electrofisher (400 v output) from a stretch of Young's Brook midway between Sites 1 and 2, and placed in cages at Sites 2 and 5. Yearling parr at Site 2 were held in a cage which measured 61 x 61 x 122 cm and consisted of a wood frame of unfinished 5 x 10 cm lumber, covered with nylon screen (602 µ) on all sides except for one 61 x 122 cm side, which had a removable plywood cover. The cage was secured in the stream using a rope and with rocks placed inside the cage. Two smaller cages (40 x 40 x 60 cm) of similar design were used to hold parr at Site 5, since all available larger cages had been committed to the concurrent crayfish mortality study. Parr mortality rates were observed at the two sites.

Crayfish were obtained by electrofishing in Big Hole Brook of the Southwest Miramichi watershed. Attempts to obtain large numbers of crayfish in May in the Young's Brook study area were unsuccessful, although they were easier to capture later in the season. They were packed in damp sphagnum moss in a cooler, and transported to the study area where they were distributed to Sites 1, 2, 4, 5 and 6 and placed in cages identical to those used for 1+ salmon parr at Site 2. Cod heads were placed in the crayfish cages on 1 June as a food source, but these were not eaten and were later discarded. There was no evidence of cannibalism.

Crayfish were observed at the same time as caged 0+ salmon, and notes were made on mortality and response to stimuli. Carapace length and total weight were measured after the study was terminated.

RESULTS

Underyearling salmon mortality occurred in upwelling boxes at all sites (Table 19); it was lowest at unsprayed Site 5, and highest at Sites 1 and 4 over a period following heavy rains on 12 June. Prior to 14 June, total mortality at each site was less than 10%. Two of the caged 1+ salmon parr at the untreated Site 5 were found dead on 5 June, but no mortality occurred among the parr caged at Site 2, which received two spray applications.

The following observations were made, at all sites during the course of study, concerning the behavior and appearance of caged 0+ salmon:

1) 31 May to 4 June, most 0+ salmon lay motionless, on their sides, on the screen at the bottom of the box, or along the frame to which the screen was attached. Less than 10 individuals at each site swam actively; these were individuals whose yolk-sacs were completely absorbed. Most fry were uniformly pale brown in colour, but a small number, less than 10, were dark brown in coloration. Most fish responded only to physical disturbance.

2) 5 June - 10 June, an increasing proportion of 0+ salmon swam freely and avoided an approaching stick or finger. On 8 June the first individual with "parr marks" (a series of bars on the lateral surface) was observed. Occasional mayfly and blackfly larvae were seen in boxes, but no fish were seen feeding on these.

3) 11 June - 19 June, most caged fish were off the bottom of the box and swimming actively when the rocks covering the plexiglass were removed. All had acquired parr marks and avoided a stimulus.

There was little mortality in the crayfish cages at any of the study sites until after the second spray application (Table 20). Thereafter, higher mortality rates occurred at cages in the double application block (Sites 1 and 2) than in those at single application Site 6 and at unsprayed Site 5. This difference was not statistically significant when tested using a 2 x 4 contingency chi-square ($Chi^2 = 5.58$ H_0: mortality rates are independent of site number). Site 4 was excluded from statistical analysis because vandals removed some crayfish and killed others on or about 2 June.

Table 19. Numbers of dead Atlantic salmon fry in upwelling boxes at permethrin study sites*, in the Young's Brook watershed, 31 May-19 June 1980

	Untreated control sites		Single application Block**		Double application block***	
	Site 5	Site 4	Site 3	Site 6	Site 1	Site 2
31 May	1	2	0	0	2	3
1 June	0	1	0	0	0	0
2 June	0	0	0	0	1	0
3 June	0	2	0	0	0	0
4 June	0	2	0	3	0	1
5 June	1	0	3	2	0	4
6 June	1	0	0	0	1	1
7 June	0	1	0	0	0	0
8 June	0	3	0	0	0	2
9 June	0	1	1	0	0	1
10 June	0	1	1	0	1	0
11 June	0	0	0	0	0	1
12 June	0	1	0	0	0	0
14 June	0	22	0	0	0	1
16 June	0	24	0	1	42	0
18 June	0	0	0	2	1	1
19 June	0	0	0	3	0	0
Total mortality	3	60	5	11	48	15
Fry present 30 May	102	111	100	94	104	107
% Mortality	2.9	54.0	5.0	11.7	46.2	14.0
Mean fork length (mm)	26 ± 1.5	26 ± 1.8	5 ± 1.7	27 ± 1.3	26 ± 1.5	27 ± 0.9

*Combined data from two upwelling boxes at each site.

**Treated with permethrin at 17.5 g/ha on the evening of 3 June.

***Treated with permethrin at 17.5 g/ha on the morning of 3 June and again on the morning of 7 June.

Table 20. Numbers of dead crayfish in cages at permethrin study sites in the Young's Brook watershed, 29 May-19 June 1980

	Untreated control sites		Single application block*	Double application block**	
	Site 5	Site 4	Site 6	Site 1	Site 2
29 May	0	0	0	0	0
30 May	0	1	0	0	0
31 May	0	0	0	0	0
1 June	0	0	0	0	0
2 June	0	1	0	0	0
3 June	0	0	0	0	0
4 June	0	0	0	0	0
5 June	0	0	0	0	0
6 June	0	0	0	0	0
7 June	0	0	0	0	0
8 June	0	0	0	1	0
9 June	0	0	0	0	0
10 June	0	0	0	0	0
11 June	0	0	0	1	1
12 June	0	0	0	0	0
14 June	0	0	1	0	1
16 June	0	0	0	0	0
18 June	1	0	0	0	0
19 June	0	0	0	3	2
Total mortality	1	2	1	6	4
Crayfish present 29 May	19	20	19	22	20
% Mortality	5.3	10.0	5.3	27.3	20.0
Mean carapace length (mm)	21 ± 3.6	21 ± 3.8	20 ± 2.7	21 ± 5.0	18 ± 3.6
Mean weight (g)	3.5 ± 1.5	3.3 ± 1.3	3.2 ± 1.2	4.0 ± 2.3	1.9 ± 0.6

*Treated with permethrin at 17.5 g/ha on the evening of 3 June.

**Treated with permethrin at 17.5 g/ha on the morning of 3 June and again on the morning of 7 June.

On 3 June, the first spray day, two crayfish at both Sites 1 and 2 did not respond when prodded with a stick. Generally, crayfish would seek cover beneath rocks in the cage. Similar observations were made on individual crayfish at Sites 1 and 2 on 14 June and 11 June respectively. In one case, at Site 1 on 3 June, two crayfish swam, when prodded, to the water surface and circled upside-down. On the same day, about 50 m up stream from the cages at Site 1, a resident crayfish was observed drifting downstream. Although apparently alive, it did not respond to prodding (pers. comm. C. Weaver, Maritimes Forest Research Centre).

DISCUSSION

Mortality of underyearling salmon in upwelling boxes appeared unrelated to spray application. Site 1, which received two spray applications and where benthic invertebrate populations were markedly diminished following spray application, had as few 0+ salmon deaths as any site during the period from immediately after the first spray (3 June) until 16 June. Mortality rates at treated site 3 were similar to those at site 5, which was unsprayed. The rates at the two sites within each spray block, and the rates at the two unsprayed sites, were dissimilar, which suggests they were not a result of the experimental treatment for each block.

At sites 1 and 4 during 14-16 June most or all of the salmon in one upwelling box were dead while those in the other were alive. Mortality may have been due to suffocation from silt particles on gills, as silt tended to accumulate in boxes at these and other sites, especially following the heavy rains on or about 12 June. Boxes which had very high mortality rates may have been situated in an area of slower current, where silt would be more apt to settle than in fast flowing areas.

McKenzie Brook (Site 4) was extremely turbid following rain on 27 May, 11 June and 16 June. Objects about 40 cm below the surface were not visible. Investigation of the road crossings upstream from site 4 and conversations with area residents revealed that a bridge 4-5 km upstream had been replaced. Numerous heavy machinery tracks crossed the brook at the bridge and freshly dug drainage ditches allowed suspended material to enter the brook. The high mortality rates at Site 4 may have been related to this or other sources of suspended material.

The observations on 0+ salmon behavior and appearance confirm that swim-up occurred at all sites during the period 4 to 10 June. At swim-up, 0+ salmon fill their swim bladder for the first time (Peterson and Metcalfe 1977) and, in streams, emerge from the spawning gravel and begin feeding. There was no clear difference between sites in the behavior or appearance of 0+ salmon that could be attributed to spraying.

The cage study with 1+ salmon did not show direct spray-related mortality. Furthermore, at no time during the spray operations or during the weeks thereafter were dead juvenile salmon found at study sites, although, with the exception of site 6, electrofishing studies had confirmed their presence.

The results in Table 20 suggest, but do not conclusively demonstrate, delayed mortality of crayfish due to the double permethrin application. Crayfish mortality rates at sites 1 and 2 appeared to accelerate as the study neared termination on 19 June. Had the study continued, the apparent trend may have become more pronounced and been statistically significant. There were also some suggestions of toxic effects on crayfish in the double application block in the observations of unusual crayfish behavior at sites 1 and 2 on 3, 11 and 14 June. Permethrin residues in this block approached or exceeded 96 hour LC_{50} values reported for crayfish (Jolly et al. 1978) after both spray applications, although they did not persist above these levels for more than a few hours. It is possible that the short-term exposure of the crayfish to a sublethal concentration resulted in delayed postexposure mortality, as Symons and Metcalfe (1978) reported for caddisfly larvae exposed to fenitrothion.

Certain cage designs may protect aquatic organisms from the effects of pesticides in streams. When the upstream walls of a cage become partially blocked, the flow of pesticide to the organism may be reduced and the rate of absorption by the organism may be less. The large (61 x 61 x 122 cm) cages used for crayfish and 1+ parr had nylon screen on all submerged surfaces. Water could therefore upwell through the bottom of the cage should the upstream wall become blocked with debris. The permethrin concentration in the cage at site 2 was evidently sufficient to kill caddisfly larvae of the genus *Pycnopsyche*, as two dead larvae were found at 1000 h on 3 June inside the cage. Debris did not readily collect on the upwelling box screens, although air bubbles sometimes collected beneath the screen separating the two chambers. An improved design would allow the venting of air which collected there. Also, a larger screen mesh size may allow greater flow through the boxes and prevent silt accumulation, to which pesticide may adsorb (Muirhead-Thomson 1971).

X. FISH POPULATION AND GROWTH STUDIES

A. Sosiak
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Native fish populations were studied at permethrin-treated and untreated control sites within the Young's Brook watershed by Montreal Engineering Company, Limited (MECO) under contract to FPMI. A. Sosiak of MECO designed and supervised the study and carried out the data analysis and reporting. FPMI field staff helped collect field data.

Apart from direct lethal effects, pesticides may induce emigration (Elson et al. 1973), increase susceptibility to predators (Hatfield and Anderson 1972), reduce growth rates through reduced food supply (Symons and Harding 1974) or reduce feeding activity (Bull and McInerney 1974). To determine whether fish population density, structure, and growth were influenced by any such effects of the permethrin treatments, sites in sprayed and unsprayed areas were electrofished and population and growth estimates were calculated.

METHODS

Five of the six sites used for the caged 0+ salmon study (Fig. 24, sites 1, 2, 3, 4, 5) were used as electrofishing sites. Site 1 was about 100 m downstream from the area in which cages had been placed; at all other sites the electrofishing site included the actual caging site. Nylon seine nets (about 6 mm mesh) were used to block off a representative section of stream at each site (Fig. 3). Areas within barrier nets generally ranged from two to three hundred square metres (Appendix VII). Ten equally spaced depth measurements were taken across the stream at both barrier nets and the middle of the site, and widths were measured at 5 m intervals. Sites were electrofished in late May before spraying and in early July and late September after spraying (Appendix VII).

Fish populations in each area were estimated by the removal method (Seber and LeCren 1967), with constant electrofishing effort being applied to the area during 5-6 successive sweeps. A Smith-Root Model VII D.C. electrofisher was used for all fishings. Operating voltage varied between 300 and 500 volts (about 60 Hz), with output selection depending on water conductivity. A small hand seine (0.8 m wide) and dip net were used to catch stunned fish.

All fish collected during each sweep were held in stream cages away from the electrofishing area until the final sweep was completed. Each captured salmon or trout was anesthetized with tertiary-amyl alcohol and the fork length (nearest mm) and weight (nearest 0.1 g) were measured. Underyearling salmon were weighed in batches of 10 in July because of their small size. All salmonid fish were adipose fin-clipped to identify those fish which had previously been captured. Scale samples were taken from salmon and trout which appeared to be either very large or very small for an apparent age class. Scales taken from the lateral surface of the caudal peduncle, just above the lateral line and between adipose and dorsal fins, were stored on pieces of acetate, covered with clear plastic film and later read using a dissecting microscope or a Bausch and Lomb scale slide projector. This information was used to assign ages to other fish in the sample. After they recovered from the anesthetic, captured fish were released at the approximate center of the electrofishing area.

Population estimates and confidence limits were calculated for all species and age classes by computer, using the Zippin method (Zippin 1958). A program for the Zippin estimate was supplied by R.G. Randall (Fisheries and Oceans, St. Andrews, N.B.). Population estimates were converted to fish per 100 m^2, using the stream area determined at each site during summer low water as a standard value of the available area of fish habitat for that site.

Growth over the course of the sampling period was assumed to be exponential (Ricker 1971). To facilitate comparisons in the rates of growth between sites, an instantaneous growth coefficient (G) was calculated using the following formula:

$$G = \frac{\log_e W_2 - \log_e W_1 \times 100}{\Delta T}$$

where W_1, W_2 = mean weights of the fish at times t_1 and t_2 respectively (Ricker 1971). Coefficients have been multiplied by 100 for ease of presentation. Instantaneous growth coefficients were calculated for each class of salmon and trout for each sampling interval where samples of 4 or more individuals were obtained.

The mean weights of 1+ and 2+ salmon and trout at the five sites were compared during each sampling period (where $n > 4$) using a two-tailed one-way analysis of variance (ANOVA, H_o: the mean sample weight is the same for all sites) and the Newman-Keuls multiple range test for unequal sample sizes.

Condition factors were calculated using Fulton's coefficient of condition (Ricker 1971):

$$K = w/l^3 \times 10^5$$

where W = weight and l = fork length (10^5 is used to bring the factor closer to unity). These were used to indicate general differences in the condition of salmon and trout between sites and sampling periods.

RESULTS

Zippin population estimates and actual catches of salmon, trout and other fish species at each of the study sites were converted to fish/ 100 m^2 (Tables 21-23). Zippin population estimates have been presented

Table 21. Zippin population estimates and actual catch of salmon per 100 m^2 from permethrin treated and untreated control sites, Young's Brook watershed, N.B. May-September 1980.

	May		July			September		
Age Class	1+	2+, 3+	0+	1+	2+, 3+	0+	1+	2+, 3+
Double application block								
Site 1	19.4 (1.0)*	9.9 (1.0)	27.9 (0.0)	7.2 (0.4)		41.3 (1.5)	14.1 (1.8)	11.8 (0.1)
	19.0**	9.5	27.8	7.0	2.6	40.6	13.5	11.7
Site 2	-	5.9 (1.0)	-		-	-	4.5 (0.0)	6.1 (0.1)
	3.0	5.5	0	4.5	2.0	5.5	6.5	6.0
Single application block								
Site 3	8.5 (4.8)	-		-	-		8.3 (1.4)	12.6 (10.2)
	7.9	6.9	0	6.9	8.2	0	7.9	11.3
Untreated control sites								
Site 4	10.2 (0.1)	13.2 (1.6)	-	12.2 (2.2)	13.9 (3.5)	6.4 (0.0)	11.0 (0.1)	11.6 (3.6)
	10.2	12.7	1.1	11.6	13.1	6.4	10.9	10.9
Site 5	0.4 (0.0)	-		-	-		-	-
	0.4	8.3	0	1.7	5.4	0	5.4	9.5

*Zippin estimate (standard error)
**actual catch (converted to fish/100 m^2)
- hyphen indicates that population estimate and standard error could not be calculated from the available data

Table 22. Zippin population estimates and actual catch of trout per 100 m^2 from permethrin treated and untreated control sites, Young's Brook watershed, N.B. May-September 1980.

	May			July			September		
Age Class	0+	1+	2+, 3+	0+	1+	2+, 3+	0+	1+	2+, 3+
Double application block									
Site 1	-		1.1 (0.0)*						-
	0.4	0	1.1**	0	0	0	0	0	0.4
Site 2			-	4.8 (0.6)		-	1.0 (0.0)	-	-
	0	0	3.5	4.5	0	1.0	1.0	0.5	0.5
Single application block									
Site 3		7.3 (1.6)	2.5 (0.1)	12.7 (0.0)	4.5 (0.0)	1.0 (0.0)	6.0 (0.2)	3.6 (0.4)	0.4 (0.0)
	0	6.9	2.4	12.7	4.5	1.0	5.8	3.4	0.3
Untreated control sites									
Site 4		-	1.8 (0.0)				0.7 (0.0)	-	
	0	1.1	1.8	0	0	0	0.7	0.4	0
Site 5		4.0 (0.4)	-	26.5 (1.0)	12.5 (5.2)	-	-	-	8.2 (0.8)
	0	3.7	9.5	26.1	11.6	7.9	4.6	7.5	7.9

*Zippin estimate (standard error)
**actual catch (converted to fish/100 m^2)
- hyphen indicates that population estimate and standard error could not be calculated from the available data.

Table 23. Zippin population estimates and actual catch of non-salmonid species per 100 m^2 from permethrin treated and control sites, Young's Brook watershed, N.B. May-September 1980.

	Month	Slimy sculpin	Blacknose Dace	American Eel	Crayfish	Sea Lamprey (juvenile)	White Sucker
Double application block							
Site 1	May	1.0 (0.7)* 0.7**	- 7.7	11.5 (0.3) 11.3	NA	NA	1.0 (0.7) 0.7
	July	- 0.4	14.3 (1.1) 13.9	11.0 (0.0) 11.0	19.1 (1.2) 18.7	5.7 (0.3) 5.5	0
	Sept	2.1 (0.5) 1.8	20.2 (1.0) 19.8	- 4.8	20.0 (27.3) 14.3	2.3 (0.2) 2.2	0
Site 2	May	16.3 (2.6) 15.5	5.0 (0.0) 5.0	0.5 (0.0) 0.5	NA	NA	
	July	21.3 (2.2) 20.5	14.8 (2.9) 14.0	2.1 (0.1) 2.0	14.5 (4.1) 13.5	0	
	Sept	9.7 (0.4) 9.5	6.0 (0.0) 6.0	- 0.3	- 5.0	0	
Single application block							
Site 3	May	33.7 (4.7) 30.1	0	2.1 (0.0) 2.1	0	NA	
	July	23.9 (0.3) 23.6	1.1 (0.0) 1.0	5.3 (0.1) 5.1	0	- 7.2	
	Sept	20.8 (2.6) 19.9	- 1.0	2.1 (0.0) 2.1	- 1.0	- 1.4	
Untreated control sites							
Site 4	May	- 0.4	- 2.9	12.5 (5.6) 11.6	NA		NA
	July	2.2 (0.0) 2.2	16.4 (0.0) 16.3	4.9 (0.2) 4.7	- 7.3		0
	Sept	- 1.1	21.9 (3.5) 20.3	- 8.4	- 5.4		0
Site 5	May	26.9 (6.6) 22.5	0	- 3.3	NA	NA	
	July	30.2 (4.8) 26.9	0.4 (0.0) 0.4	9.3 (5.2) 8.7	- 10.5	- 2.1	
	Sept	17.0 (6.2) 14.9	0	- 2.9	- 3.3	- 4.6	

*Zippin estimate (standard error)
**actual catch (converted to fish/100 m^2)
- hyphen indicates that population estimate and standard error could not be calculated from the available data.
NA - present at site but data not collected.

only where confidence limits could be calculated for the estimate. Since 3+ salmon and trout were infrequent at all sites (Table 24), they have been grouped with 2+ parr in population tables.

Data on the numbers of salmon and trout marked at each site and recaptured at subsequent sampling periods are presented in Table 25.

Population densities of 1+ and 2+ - 3+ salmon parr declined to a greater extent between May and July at site 1 in the double application block than at any of the other electrofishing sites (Table 21). By September, however, populations at site 1 had returned to near prespray numbers. In July and September, fewer marked parr were recaptured at sites 1 and 2 than at sites 3 and 4 (Table 25). At all sprayed sites (Sites 1, 2, 3) and to some extent at unsprayed site 5, parr numbers increased between July and September. A majority of the immigrants to sites 1, 2, and 3 were 2+ parr. Parr populations at unsprayed site 4, in a separate branch of the watershed, remained relatively stable throughout the May to September period. There was also a greater percent recapture rate in September than in July at all sites except site 4 (Table 25). No 0+ salmon were captured before spraying. Later in the season, site 1 had a higher rate of 0+ recruitment than other sites, although no spawning gravel was apparent near site 1.

Brook trout population density at site 3 decreased throughout the season, and to a greater extent than occurred at unsprayed site 5 (Table 22). The percent recapture of 1+ and 2+ trout was also lower at site 3 than at site 5 (Table 25). All of the other sites had few brook trout.

Slimy sculpins, *Cottus cognatus* (Richardson), blacknose dace, *Rhinichthys atratulus* (Hermann), American eel, *Anguilla rostrata* (LeSueur), and crayfish were collected at all sites during the season (Table 23). Juvenile sea lampreys, *Petromyzon marinus* (Linnaeus), and white suckers, *Catostomus commersoni* (Lacepede), occurred at some sites, and adult lampreys were present at site 1 in May. An adult (4+) chain pickerel, *Esox niger* (Lesueur), a species rarely encountered in salmon nursery streams, was captured at site 3 in July. Relative numbers of nonsalmonid species and temporal population trends differed greatly between sites and did not appear to be clearly related to the spray program. Most species were either as abundant or more abundant in July than in May, and then declined in numbers between July and September.

In May, mean 1+ salmon fork length, weight, and condition factors varied considerably from site to site (Table 26). Differences in weight between all sites were highly significant (Table 27) when tested with ANOVA ($p < 0.001$). Fork lengths and weight of 2+ salmon differed little between sites ($p > 0.05$) in May. Two plus salmon condition factors varied considerably between sites, as did those of 1+ salmon. In July, after spraying, both 1+ and 2+ salmon mean fork length and weight were lower at sites 1 and 3 than at unsprayed sites. Both 1+ and 2+ salmon weight

Table 24. Numbers of salmonids captured at fish population sites in Young's Brook watershed, York County, N.B. May-September 1980

Month	Age	Site 1	Site 2	Site 3	Site 4	Site 5
Salmon						
May	1+	52	6	23	28	1
	2+	26	11	18	32	20
	3+	-	-	2	3	-
July	0+	65	-	-	3	-
	1+	19	9	20	32	4
	2+	6	4	24	34	13
	3+	-	-	-	2	-
Sept	0+	105	11	-	12	-
	1+	37	9	23	30	13
	2+	32	11	33	28	21
	3+	-	1	-	2	2
Trout						
May	1+	-	-	20	3	9
	2+	3	6	4	4	20
	3+	-	1	3	1	3
July	0+	-	9	35	-	63
	1+	-	-	13	-	28
	2+	-	2	3	-	19
Sept	0+	-	2	17	2	11
	1+	-	1	10	1	18
	2+	1	1	1	-	18
	3+	-	-	-	-	1

Table 25. Numbers of salmonids marked and recaptured at fish population sites in Young's Brook watershed, York County, N.B. May-September 1980

Species	Site	Age	No. of Fish Marked in May	No. of Marked Fish Recaptured In July	% Recaptured	No. of Additional Fish Marked In July	No. of Marked Fish Recaptured In September	% Recaptured (as % of total marked in May and July)
Salmon	1	1+	52	6	12	13	15	23
"	1	2+	26	3	12	4	8	27
"	2	1+	6	1	17	8	3	21
"	2	2+	11	0	0	4	5	33
"	3	1+	23	7	30	13	15	42
"	3	2+	18	5	28	19	22	60
"	4	1+	28	10	36	22	22	44
"	4	2+	32	16	50	18	21	42
"	5	1+	1	1	100	2	3	100
"	5	2+	20	5	20	9	11	38
Trout	2	2+	6	1	17	1	1	14
"	3	0+	-	-	-	35	3	9
"	3	1+	20	2	10	11	4	13
"	3	2+	4	1	25	2	1	17
"	5	0	-	-	-	63	1	2
"	5	1+	9	6	67	22	6	19
"	5	2+	20	16	80	3	7	30

Table 26. Fork lengths (mm), weights (g) and condition factors (means and standard deviations) of salmon at fish population sites in Young's brook watershed, York County, N.B. May-September 1980.

Age	Month	Site 1	Site 2	Site 3	Site 4	Site 5
Length (SD)						
0+	July	30 (1.2)	-	-	S	-
0+	Sept	53 (4.2)	60 (4.0)	-	61 (3.1)	-
1+	May	63 (4.1)	69 (5.7)	58 (3.3)	67 (4.2)	S
1+	July	75 (5.4)	83 (14.3)	79 (10.2)	85 (4.5)	98 (10.2)
1+	Sept	87 (5.7)	93 (4.7)	86 (8.2)	93 (5.3)	95 (7.4)
2+	May	95 (6.1)	95 (5.7)	94 (6.4)	98 (5.8)	98 (7.5)
2+	July	105 (8.5)	114 (2.6)	110 (6.0)	114 (7.9)	119 (9.8)
2+	Sept	119 (11.2)	121 (7.9)	117 (6.7)	118 (9.1)	122 (9.3)
Weight (SD)						
0+	July	0.39 (-)	-	-	S	-
0+	Sept	1.9 (0.6)	2.7 (0.6)	-	2.4 (0.4)	-
1+	May	2.6 (0.5)	4.1 (1.5)	2.1 (0.5)	3.3 (0.7)	S *
1+	July	4.2 (1.1)	7.0 (4.1)	5.8 (2.6)	6.9 (1.1)	10.1 (2.8) *
1+	Sept	7.7 (2.0)	9.5 (1.6)	7.4 (2.2)	8.7 (1.4)	10.0 (2.2) *
2+	May	9.4 (1.9)	10.3 (2.0)	9.7 (2.3)	10.2 (1.9)	11.0 (2.8)
2+	July	13.6 (1.7)	16.9 (1.4)	14.7 (2.5)	16.7 (3.7)	19.7 (4.8) *
2+	Sept	17.9 (4.5)	18.7 (4.0)	17.0 (2.9)	18.2 (4.5)	19.7 (4.2)
Condition Factor (SD)						
0+	July	1.44	-	-	-	-
0+	Sept	1.25(0.35)	1.27(0.25)	-	1.08(0.12)	-
1+	May	1.00(0.11)	1.18(0.12)	1.08(0.14)	1.07(0.13)	S
1+	July	0.96(0.10)	1.11(0.10)	1.10(0.08)	1.13(0.06)	1.05(0.06)
1+	Sept	1.19(0.21)	1.19(0.10)	1.15(0.11)	1.10(0.08)	1.16(0.11)
2+	May	1.08(0.08)	1.21(0.09)	1.17(0.09)	1.08(0.09)	1.16(0.13)
2+	July	1.08(0.12)	1.14(0.11)	1.11(0.06)	1.11(0.07)	1.15(0.08)
2+	Sept	1.06(0.13)	1.05(0.08)	1.06(0.10)	1.08(0.12)	1.09(0.10)

S - Sample size <4

*p <0.001 sites differ significantly (see Table 27)

Table 27. Newman-Keuls multiple range test of ANOVA comparison of 1+ and 2+ salmon mean weights

Age	Month	Result of test
1+	May	Site 1 ≠ site 2 ≠ site 3 ≠ Site 4
1+	July	Site 1 ≠ sites 3, Site 5 ≠ sites 2, 3, and 4
1+	September	Site 1 ≠ sites 2, 4, and 5 Site 2 ≠ site 3 Site 3 ≠ sites 4 and 5
2+	July	Site 1 ≠ sites 2, 3 and 5 Site 3 ≠ sites 4 and 5 Site 4 ≠ site 5

Table 28. Instantaneous growth coefficients* of salmon and brook trout at fish population sites in Young's Brook watershed, York County, N.B. May-September 1980

		Salmon		Brook Trout	
Age	Site	May-July	July-September	May-July	July-September
0+	1	-	1.91	-	-
	3	-	-		1.42
	5	-	-	-	0.97
1+	1	1.12	0.73	-	-
	2	1.27	0.37	-	-
	3	2.36	0.30	1.06	0.47
	4	1.72	0.28	-	-
	5	-	-0.01	1.80	0.18
2+	1	0.86	0.33	-	-
	2	1.18	0.12	-	-
	3	0.97	0.18	-	-
	4	1.15	0.10	-	-
	5	1.36	0.00	1.02	-0.01

* Growth coefficients were only calculated when at least four fish were obtained in each month.

differed significantly between study sites (Table 27) in July ($p < 0.001$). The growth rates of 1+ and 2+ salmon were lower at site 1 during the May-July period than at any other site (Table 28), while at site 3, 1+ salmon growth rates were higher than at any other site. Salmon condition factors did not consistently reflect the changes in weight which occurred between May and July.

Mean salmon fork length and weight had increased at treated sites to such an extent by September that 2+ salmon at sprayed and unsprayed sites were no longer significantly different from one another in weight. Significant differences in weight between sites remained for 1+ salmon (Table 27). Growth rates of 2+ salmon at sites 1 and 3 were higher during the July-September period than at unsprayed sites. At site 1 during the same period, 1+ salmon growth rates were higher than those at any other site. One plus salmon condition factors increased during the July-September period at all sprayed sites and at site 5. During the same period, 2+ salmon at all sites decreased in condition factor.

Since only sites 3 and 5 had sizeable brook trout populations, meaningful comparisons between sprayed and unsprayed sites are difficult. One plus and 2+ brook trout differed in fork length and weight in May and July (Table 29), but 1+ trout did not differ to the same extent in September. None of the weight differences were significant when tested with ANOVA ($p > 0.05$). As with salmon at site 1, 1+ brook trout at site 3 had a lower instantaneous growth coefficient than those at site 5 during the May-July period, but a higher growth coefficient during the period July-September. The condition factor of 1+ trout at both site 3 and 5 decreased as the season progressed.

DISCUSSION

The decrease in salmon parr abundance at site 1 in July was likely due to downstream emigration or movement into unsprayed tributaries. No fish mortality related to spraying was observed in caged-fish studies (Section IX) and no dead fish were found in the streams after spraying. Total parr abundance at site 5, upstream from sites 1 and 2, did not drastically increase in July as would likely have occurred with large scale upstream migration from the spray block. Symons and Harding (1974) reported a 50% increase in trout population density (1+ and older) upstream from an area where fenitrothion was dripped into the stream to produce pesticide concentrations in water about 100 times that usually found after forest spraying. Parr emigration from site 1 is also suggested by the low frequency of recapture at that site in July. Although the total number of parr captured at site 2 in July was not greatly different than the total in May, only one of the 17 parr marked in May had remained after the site was sprayed, indicating substantial movement of previously resident fish out of the area.

Symons (1971) demonstrated salmon parr emigration from an area of experimentally reduced food supply. In the permethrin study area, the

Table 29. Fork lengths (mm) weights (g) and condition factors (means and standard deviations) of brook trout at fish population sites in Young's Brook watershed, York County, N.B. May-September 1980

Age	Month	Site 1	Site 2	Site 3	Site 4	Site 5
Length (SD)						
0+	July	-	50(5.5)	47(4.2)	-	47(5.9)
0+	Sept.	-	S	65(6.2)	S	67( )
1+	May	S	-	75(7.9)	S	69(13.8)
1+	July	-	S	87(10.4)	-	93(13.5)
1+	Sept.	-	S	101(12.3)	S	102(10.7)
2+	May	S	119(12.4)	104(9.3)	110(14.6)	110(12.5)
2+	July	-	S	S	-	131(8.6)
2+	Sept.	S	S	S	-	133(8.3)
Weight (SD)						
0+	July	-	1.3(0.5)	1.0(0.3)	-	1.4(0.5)
0+	Sept.	-	S	3.2(0.8)	-	3.1(0.8)
1+	May	-	-	4.7(1.4)	S	4.2(2.3)
1+	July	-	-	7.4(2.8)	-	9.1(3.8)
1+	Sept.	-	S	10.9(3.7)	-	10.5(2.9)
2+	May	S	17.8(3.0)	12.0(2.2)	15.3(7.9)	16.3(7.0)
2+	July	-	S	S	-	25.3(7.0)
2+	Sept.	S	S	S	-	25.1(6.4)
Condition Factor (SD)						
0+	July	-	1.03(0.09)	0.94(0.12)	-	1.27( )
0+	Sept.	-	S	1.18(0.19)	-	1.03(0.13)
1+	May	-	-	1.07(0.10)	S	1.12(0.22)
1+	July	-	-	1.06(0.07)	-	1.08(0.10)
1+	Sept.	-	S	1.03(0.08)	S	0.95(0.09)
2+	May	S	1.16(0.12)	1.08(0.10)	1.05(0.15)	1.16(0.12)
2+	July	-	S	S	-	1.10(0.15)
2+	Sept.	S	S	S	-	1.03(0.11)

S - Sample size <4

invertebrate populations both upstream and downstream from site 1 were markedly reduced by two applications of permethrin (Section VI). Since salmon parr feed mainly on aquatic and terrestrial invertebrates, the emigration of salmon parr may have resulted from reduced food supply. Salmon parr normally defend territories in streams (Kalleberg 1958), and food-deprived salmon parr have been shown to increase in the aggressiveness of their territorial defence (Symons 1968) and to increase territory size (Symons 1971). Thus, individuals may be forced to leave the area because of reduced food supplies. Symons (1971) also suggested that with sufficient reduction in food supplies over a long period dominant fish might leave an area and socially subordinate fish move back in, but grow at substantially lower rates.

Salmon parr numbers at sites 2 and 3 did not change to the same extent as at site 1 between May and July. Two plus salmon at site 2 declined in numbers by 50%, while 1+ salmon increased by 50%. However, salmon population density was much lower in May at site 2 than at sites 1 and 4. Increased territory size after food deprivation might not force individuals from an area of lower stocking density, since there is room for expansion. A different explanation may account for the lack of change at site 3. Aquatic invertebrate populations in that block were far less affected by spraying than were those in the double application block (Section VI), suggesting that food supply may not have been reduced sufficiently to force emigration from site 3.

By September, 2+ salmon parr populations actually exceeded prespray values at all Young's Brook and McCallum Brook sites and 1+ salmon populations at most sites had returned to prespray numbers. Recovery at these sites suggests a return of 1+ and 2+ salmon parr to the sprayed portions of the Young's Brook watershed, perhaps related to the partial recovery of aquatic invertebrate populations. On the other hand, salmon populations at site 4 (unsprayed), on McKenzie Brook, exhibited little fluctuation, except for a gradual reduction probably due to natural mortality.

Population estimates could not be reliably calculated using data collected at certain sites. Water depth and velocity, visibility, size of fish (Seber and LeCren 1967), species (Karlstrom 1976), and operator experience all influence efficiency of capture. Site 2 had dense alder thickets along the shore which interfered with fish capture; site 5 had several deep pools in which the electrofisher was less efficient. In such cases, more fish were sometimes captured on the last few sweeps than earlier in the electrofishing. Such variability resulted in negative variance, thus precluding calculation of the Zippin estimate with a confidence interval.

The growth rate of 1+ and 2+ salmon parr at site 1 was clearly lower during May-July than at the other study sites. Two plus salmon at Site 3 also appeared to grow slowly, although this was not the case for 1+ salmon. Reduced food supply in these cases appears to have resulted in a lower growth rate, as Symons and Harding (1974) reported for 0+ trout in a fenitrothion-treated stream. Growth rates for salmon at site 2 did not appear to be markedly lower than those at other sites. As previously observed, population density at site 2 was lower than at sites 1, 3 and 4, much lower than Symons and Heland (1978) criteria (11 1+ parr and 5 2+ parr/100 m^2) for a well-stocked, productive salmon stream in New Brunswick. The food supply available at this site after spraying may have been sufficient to support its low density salmonid population. Growth rates at sites 2 and 5 also appear to have been higher prior to the beginning of the study, as mean weight and fork length were higher than at other sites. This may reflect less competition for available food resources (Allen 1951; Cooper et al. 1962) than at densely stocked sites.

Between July and September, salmon at treated sites where salmon growth had earlier been poor exhibited higher rates of growth than those at unsprayed sites, so that by September, 2+ salmon at sprayed and unsprayed sites differed little in weight and length. At all sites, 2+ salmon had exceeded 10 cm, the lower size limit in the fall for those salmon which are apt to smoltify the following spring (Elson, 1957). Failure to smoltify would result in another year of stream life, subject to rates of predation, which Elson (1962) estimated as high as 60% for the final year of stream life prior to smoltification.

Too few sites were well-stocked with brook trout to fully assess the impact of permethrin on trout in the sprayed streams. The lower rate of recapture and decreased trout population density at site 3 suggest a higher rate of emigration from that site after spraying. Some of the trout in the double application block may have migrated upstream to site 5, as 1+ trout were much more numerous in July than in May at that site. Symons and Harding (1974) also reported increased numbers of 1+ trout at their upstream untreated site after spraying. However, brook trout in streams may migrate to cooler parts of a watershed in summer (Scott and Crossman, 1973), and this tendency may complicate detection of migration due to spraying. Trout 2+ and older were less abundant in July than in May at all sites. Trout anglers were often present in the study area and would tend to select large fish, thus reducing the number of older fish.

The data from sites 3 and 5 suggest trout growth inhibition at site 3 similar to that of salmon at site 1, followed by a recovery period later in the season. Weight differences between sites for 1+ and 2+ trout were not significant when tested with ANOVA, which may partly reflect a considerable size variation within each sample.

The tendency for nonsalmonid fish species to increase in abundance from May to July was likely a result of recruitment during this period. In May, 0+ sculpins and dace may have been too small for capture or had not left spawning areas. To avoid confounding effects due to recruitment, future studies should use the length frequency distribution (Ricker 1971) or another appropriate method to describe the population structure of non-salmonid species.

Condition factors were not effective in assessing the effects of permethrin on fish. Ricker (1971) notes that in fish species which grow isometrically (length and weight increase proportionately), as do certain salmonids, comparisons using condition factor will mainly reflect individual variability within samples. A further confounding variable, in the case of juvenile salmon, is precocious male sexual maturation. From 50 to 67% of 1+ parr captured in September were precocious males. The mean condition factor of mature 1+ males at site 1 was 1.25, compared to 1.13 for immature parr. Sexual maturation may partially account for the general increase in 1+ parr condition factors in September. The decrease in 2+ salmon condition factors which occurred during the same period may have been related to the decrease in condition factor normally associated with smoltification (Wedemeyer et al. 1981).

These results suggest that double applications of permethrin can temporarily reduce juvenile salmon population densities and growth rates in a stream. The long-term consequences are difficult to assess. Partial recovery, in terms of length, weight and growth rate had occurred at site 1 by September, and 2+ parr had reached a size sufficient for smoltification the following spring. Since their numbers were similar to those before spraying, the smolt production of site 1 may not have been impaired. However, monitoring of the annual smolt run in these streams before and after spraying would be necessary to determine if this were the case.

The impact on salmon populations would possibly be different if an entire salmon-producing watershed were sprayed with permethrin. If all contiguous areas of suitable salmon habitat were affected to the extent seen in the double application block, emigration would possibly not benefit an individual. Fish attempting to establish in a new area are at a strong disadvantage to residents, due to the effects of prior residence (Braddock, 1949; Philips 1971). Lacking territory, emigrating fish might subsequently die from exhaustion (Miller 1958) or predation (Symons 1974).

XI. TERRESTRIAL INVERTEBRATE KNOCKDOWN STUDIES

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Forest Pest Management Institute

Limited studies were carried out by FPMI's Environmental Impact group to measure and assess the significance of knockdown effects of the permethrin treatments on terrestrial arthropod communities.

METHODS

Circular plastic sampling buckets measuring 35 cm diameter x 22 cm height set out on the ground beneath trees of selected species were used to assess the knockdown of nontarget arboreal and flying invertebrates in the double application block (Fig. 28). Four sampling sites were established in the block, two under balsam fir trees and two under flowering pin cherry trees. The organisms from the 5 samples at each site were collected every evening for a number of days prior to and following the applications and later counted, identified, and reported as the number of organisms per sampler. Similar samples were collected in the control area.

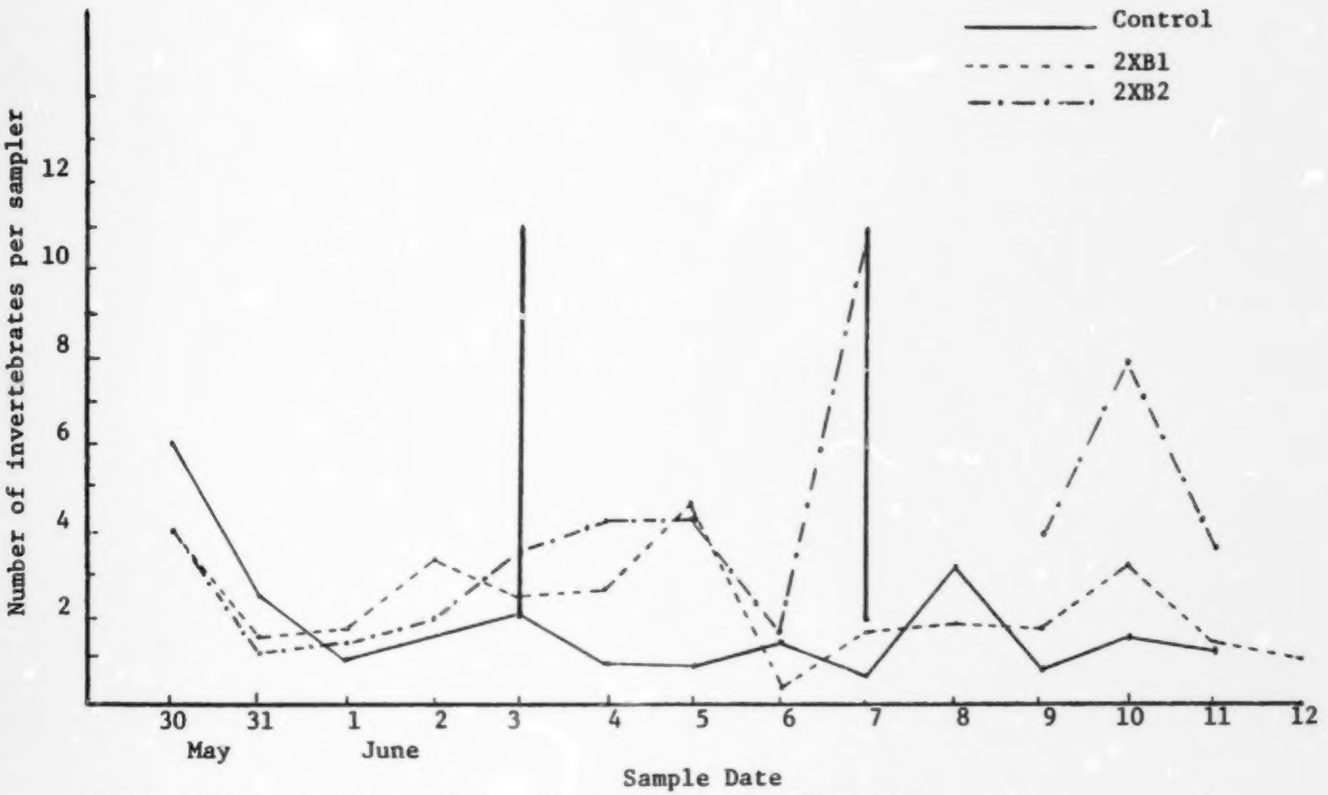
Supplementary knockdown samplers consisting of a 1 m square wooden frame overlaid with a plastic sheet were placed under balsam fir trees in the single and double application blocks and the control (Fig. 29). Single drop sheets were placed under two balsam fir trees in each block immediately prior to the applications. Organisms were collected daily from the drop sheets for two days after the application in the single block, for three days after both applications in the double block, and from the control during the same time periods. The arthropods were counted, identified, and tabulated as the total number of organisms collected from the two drop sheets in each block. Five days after the second application to the double block, all sample trees in both treatment and control areas were subjected to a high-dosage emulsifiable concentrate permethrin application from a hand sprayer, similar to the technique described by Varty (1975, 1980). The resultant arthropod fallout collected on the drop sheets provided an indication of the residual, or in the case of the control area, the natural invertebrate community present in the trees.

RESULTS

Terrestrial arthropods in the double application block demonstrated negligible to moderate knockdown from pin cherry blossom (0-4.9 times higher than the prespray average) following the permethrin applications (Fig. 30). The largest increase occurred in one of two pin cherry knockdown sampling areas immediately after the second application and consisted mainly of adult Diptera and Hymenoptera. Other major taxa represented in the invertebrate knockdown from pin cherry blossom included Lepidoptera, Coleoptera, and Hymenoptera (Appendix VIII, Tables 1-3). Although the results from the knockdown collection were somewhat variable, the numbers

Fig. 28. Terrestrial invertebrate knockdown bucket set out under pin cherry blossom in permethrin study area, York County, N.B. 1980.

g. 29. Metre square plastic drop sheet set out under a balsam fir in the permethrin study area, York County, N.B. 1980.



Vertical lines indicate 17.5g AI/ha permethrin application

Figure 30. Terrestrial invertebrate knockdown from pin cherry in double application and control blocks, York County, New Brunswick, 30 May to 12 June 1980

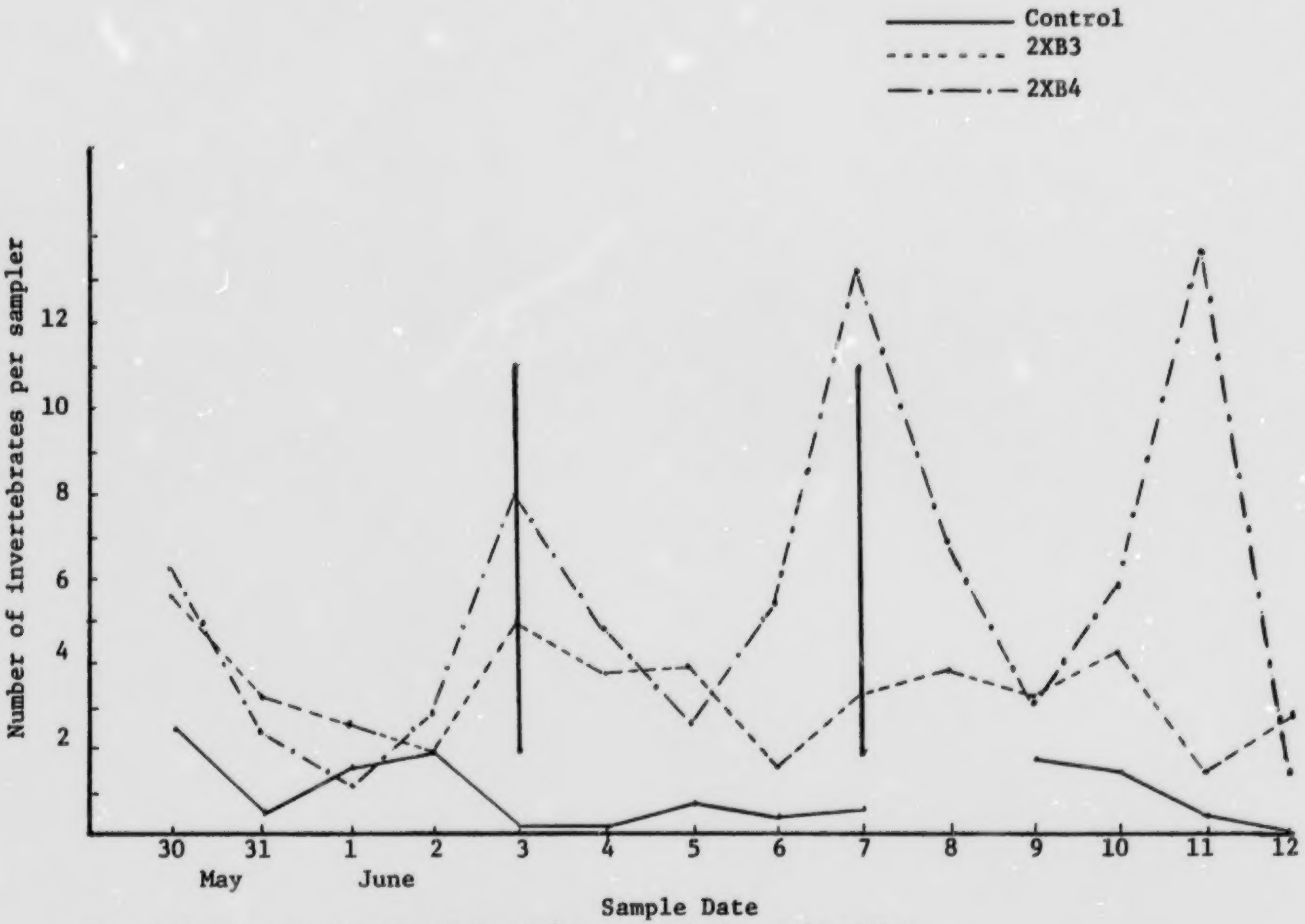
indicate that pesticide-induced knockdown did not persist beyond 48 h. An increase in numbers of adult dipterans in knockdown buckets occurred in both sample areas in the double block three days after the second application, but corresponded to a similar though smaller increase at the control site and may have been the result of high winds.

The knockdown of arboreal and flying invertebrates from balsam fir foliage in the double application block was similar in composition and magnitude to that from pin cherry (Fig. 31). Postspray peaks ranged from 1.5 to 4.2 times higher than the prespray averages and were comprised mainly of Diptera and Hymenoptera adults, and Lepidoptera larvae (Appendix VIII, Tables 4 and 5). Peak increases occurred immediately following the applications with numbers returning to normal within 48 h. A major increase recurred in one of two balsam fir sample areas 4 days after the second application, but consisted almost entirely of Collembola, litter dwelling insects, which probably jumped into the buckets from the ground. Numbers of terrestrial arthropods in the control area collections were consistently low throughout the sampling period (Appendix VIII, Table 6).

Samples of terrestrial invertebrates from large drop sheets placed beneath single balsam fir trees also indicated an increase in invertebrate knockdown immediately after the applications (Appendix VIII, Tables 7-9). Average numbers of terrestrial arthropods collected in a two or three day postspray period in both the single and double application blocks were substantially higher than the collections made during the same period in the control area (Table 30).

The manually applied permethrin treatment to the sample trees in the control area on 12 June (nine days after the aerial application to the single block and five days after the second aerial application to the double block) resulted in a major increase in the knockdown of terrestrial invertebrates over the samples collected during the pretreatment periods (Table 30). Following the manual hand-sprayer treatment to the sample trees in the double application block, the numbers of all invertebrates except spruce budworm collected on the drop sheets were considerably greater than the average numbers collected during the three day periods subsequent to both aerial applications.

After the manual treatments to the sample trees in the single application block, only adult dipterans demonstrated a substantial increase over the postaerial application knockdown. All other insects were collected after the manual treatment in numbers similar to or fewer than those collected following the aerial application. The total terrestrial invertebrate knockdown from the hand-sprayer treatment in the single application block greatly exceeded that from the manual treatments in the double application and control blocks. The only groups which were knocked down from trees in both treated areas in noticeably smaller numbers than in the control area were adult Coleoptera and the target insect, spruce budworm.



Vertical lines indicate 17.5g AI/ha permethrin application

Figure 31. Terrestrial invertebrate knockdown from balsam fir in double application and control blocks, York County, New Brunswick, 30 May to 12 June 1980

Table 30. Terrestrial arthropods* collected from drop sheets placed under single balsam fir trees in sample areas, York County, New Brunswick, 1980

	Control			Double Application Block			Single Application Block	
Sample dates	Post First Application 3-5 June	Post Second Application 7-9 June	Manual Treatment** 12 June	Post First Application 3-5 June	Post Second Application 7-9 June	Manual Treatment** 12 June	Post Application 4-5 June	Manual Treatment** 12 June
Number of sample days	3	3	1	3	3	1	2	1
Arachnida: Phalangida							0.50	
Acari				0.33		6	0.50	3
Araneida	0.33	0.67	7	2.33	1.33	19	6.00	7
Collembola		1.00	1	1.00	1.00	7	2.00	3
Homoptera - Total adults	0.67		8	4.00	5.00	13	19.00	10
Cicadellidae				2.67	1.00		11.00	2
Aphididae	0.67		6	1.33	3.67	13	7.50	8
Other			2		0.33			
Coleoptera - Total adults	0.33	0.67	22	0.67	1.00	10	5.00	1
Carabidae					0.67	1	3.50	
Curculionidae			1					
Elateridae		0.33	1	0.67	0.33			1
Staphylinidae							0.50	
Other	0.33	0.33	20			9	1.00	
Unidentified larvae					0.33		0.50	
Trichoptera adults					0.33			4
Lepidoptera - Total larvae	0.67		78	13.00	11.30	7	37.00	22
Choristoneura fumiferana	0.67		77	12.00	10.70	7	35.50	21
Geometridae			1	1.00	0.33		1.50	1
Other					0.33			
Diptera - Total adults	2.33	2.67	28	17.70	30.30	101	129.50	227
Tipulidae								1
Bibionidae							0.50	
Culcidae					0.67		0.50	
Chironomidae	0.67	0.33		0.67	0.33	4	21.50	44
Sciaridae	0.33	1.67	10	9.00	16.00	76	27.00	68
Other	1.33	0.67	18	8.00	13.30	21	80.00	114
Unidentified larvae					0.33	5	0.50	
Hymenoptera - Total adults	0.33	0.67	4	1.67	3.33	6	11.00	7
Formicidae	0.33	0.33		0.33	0.33			
Other		0.33	4	1.33	3.00	6	11.00	7
Totals	4.67	5.67	151	40.7	54.3	173	211.50	285

*expressed as mean number of organisms collected from two drop sheets during sample period.

**high-dosage emulsifiable concentrate permethrin solution applied with a hand sprayer to the sample trees.

Incidental observations made during aquatic sampling on the abundance and activity of adult blackflies in the treated blocks suggested that the permethrin treatments greatly reduced their numbers for up to at least three days after treatments.

DISCUSSION

The permethrin applications in the double block resulted in a slight to moderate knockdown of arboreal and flying invertebrates. Composition and duration of knockdown from pin cherry blossom and balsam fir foliage were similar. The magnitude of the increases was comparable to that observed by Kingsbury and Kreutzweiser (1980) and by Kreutzweiser (1982) in previous experimental permethrin applications, but considerably less than that reported by Kingsbury and McLeod (1979). From both the present and previous impact assessments of permethrin applications, it is apparent that flying insects, mainly Diptera and Hymenoptera, followed by Homoptera and Coleoptera, comprise the largest portion of nontarget insect knockdown after permethrin treatments. In almost every instance a wide variety of arboreal and flying invertebrates were killed.

The number of invertebrates collected from large drop sheets placed under single balsam fir trees for two and three day postspray periods in the single and double application blocks was considerably greater than the number collected during the same period in the control area. This substantiates indications from the terrestrial knockdown buckets that each permethrin application resulted in a measurable impact on arboreal and flying arthropods. However, since the numbers of arthropods collected on the drop sheets following a manually applied high-dosage permethrin treatment five days after the last aerial application were comparable to or greater than the numbers collected after a similar treatment of the control trees, it is apparent that the net effect of the aerial applications on arboreal and flying invertebrates in the treatment blocks was not significant at the level of investigation conducted. Most of the nontarget insect groups collected in the knockdown from the aerial applications were present in greater numbers (several were slightly reduced; none was eliminated) in the samples collected after the manual treatments, indicating either a rapid recolonization of arboreal and flying arthropods within the application blocks or strong residual populations.

XII. RECOVERY STUDIES - 1981

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Bottom fauna populations and native fish diets were sampled in late May 1981 in order to determine the persistence of and recovery from effects of the 1980 treatments. Sampling was carried out using the same methods and at the same sites used in 1980 (Sections VI and VII).

RESULTS

Bottom fauna studies

Bottom fauna densities obtained by Surber sampling on 21 May 1981 are presented in Table 31. A general comparison of the numbers of various benthic invertebrates at treated sites versus the control site does not indicate dramatic differences in their overall benthic faunas. Each of the major groups of aquatic insects (Ephemeroptera, Plecoptera, Trichoptera and Diptera) were present in appreciable numbers at all sites, but numbers of Ephemeroptera and Plecoptera were somewhat higher at the untreated control than at all other stations. Simuliidae larvae were considerably more abundant at the untreated control than at treated stations, while Oligochaeta were much more prominent at treated sites. Trichoptera: Brachycentridae were totally absent from all samples taken within or below the double application block but were present at the other sampling stations.

Bottom fauna populations at each site on 21 May 1981 were compared with populations from the same sites sampled between 24 and 26 May 1980 (Table 32). Although the total numbers of organisms found at the untreated control station were similar in both years, more Plecoptera, Trichoptera, and Ephemeroptera, and fewer Diptera were present in 1981. All benthic organisms except Diptera: Tipulidae were more abundant in the single application block in 1981 than prior to the permethrin application. The total population of benthic organisms at the double application block sampling site was higher in 1981 than in 1980 by an even greater factor than in the single application block. Both large increases in some groups of organisms (Diptera: Chironomidae, Trichoptera: Glossosomatidae, Oligochaeta and Ephemeroptera: Baetidae) and substantial decreases in other groups (Trichoptera: Brachycentridae, Diptera: Simuliidae and Ephemeroptera: Heptageniidae) occurred.

A different situation was apparent at the 1.4 km downstream site where the total benthic population and numbers of almost all groups of benthic organisms were considerably lower in 1981 than before treatment in 1980. Decreases of 50% or more were found among Simuliidae, Tipulidae, all families of Ephemeroptera and Trichoptera and Coleoptera. Only Chironomidae, which remained stable, and Oligochaeta, which increased, were not found in lower numbers than in prespray 1980. At the 4.2 km downstream site, total numbers of benthic organisms in May 1981 were comparable to

Table 31. Bottom fauna populations*, permethrin application blocks**, York County, N.B., 21 May 1981

Sample date 21 May 1981 350 day postapplication	Control	Single application block	Double application block	1.4 km downstream from double block	4.2 km downstream from double block
Ephemeroptera: Total nymphs	40.0 ± 6.2	26.3 ± 18.6	20.5 ± 15.6	14.7 ± 4.7	35.7 ± 16.8
Baetidae	1.3 ± 1.3	2.3 ± 2.5	13.2 ± 11.9	3.0 ± 1.7	23.7 ± 15.5
Baetiscidae	-	-	-	0.3 ± 0.6	-
Ephemerellidae	19.8 ± 2.9	18.7 ± 16.2	3.0 ± 1.4	3.7 ± 3.8	5.7 ± 6.3
Heptageniidae	17.5 ± 6.6	5.0 ± 6.9	1.0 ± 1.4	1.3 ± 1.2	2.3 ± 2.5
Leptophlebiidae	1.5 ± 1.3	-	3.2 ± 3.2	6.3 ± 2.9	4.0 ± 3.5
Odonata					
Gomphidae	0.5 ± 0.6	-	1.0 ± 1.4	0.3 ± 0.6	-
Plecoptera	17.2 ± 13.6	7.0 ± 1.7	6.0 ± 3.9	6.3 ± 4.7	12.3 ± 1.2
Trichoptera: Total larvae	17.0 ± 5.0	5.0 ± 1.7	19.0 ± 14.5	10.0 ± 4.6	35.0 ± 12.5
Brachycentridae	3.2 ± 4.7	0.7 ± 0.6	-	-	-
Glossosomatidae	1.8 ± 2.1	0.7 ± 1.2	14.8 ± 14.3	2.0 ± 1.7	7.3 ± 2.9
Hydropsychidae	4.0 ± 1.8	1.7 ± 1.2	1.5 ± 1.7	2.0 ± 1.7	8.0 ± 2.0
Hydroptilidae	0.2 ± 0.5	-	-	0.7 ± 1.2	-
Lepidostomatidae	0.5 ± 1.0	0.3 ± 0.6	0.5 ± 1.0	2.0 ± 2.6	6.0 ± 6.0
Limnephilidae	2.0 ± 4.0	0.3 ± 0.6	0.2 ± 0.5	2.3 ± 4.0	11.3 ± 19.6
Philopotamidae	-		-	0.3 ± 0.6	-
Rhyacophilidae	4.0 ± 1.6	1.3 ± 1.5	-	-	2.0 ± 1.7
pupae	1.2 ± 1.5	-	2.0 ± 0.8	0.7 ± 1.2	0.3 ± 0.6
Coleoptera					
Elmidae larvae	0.1 ± 0.6	-	0.2 ± 0.5	0.3 ± 0.6	0.3 ± 0.6
Diptera: Total	83.8 ± 61.7	42.7 ± 20.5	143.2 ± 87.6	68.3 ± 61.4	30.7 ± 7.5
Athericidae larvae	8.0 ± 4.2	19.3 ± 6.4	-	1.3 ± 5.8	-
Chironomidae larvae	25.2 ± 11.2	13.0 ± 11.3	123.5 ± 85.8	58.0 ± 52.1	13.0 ± 7.8
pupae	5.0 ± 4.8	0.7 ± 1.2	12.2 ± 4.6	4.0 ± 5.3	0.7 ± 1.2
Empididae larvae	2.2 ± 3.9	0.3 ± 0.6	3.0 ± 2.8	2.5 ± 0.7	3.3 ± 3.2
Heleidae larvae	-	0.3 ± 0.6	-	-	-
Simuliidae larvae	24.5 ± 21.3	6.0 ± 5.6	1.0 ± 0.8	0.3 ± 0.6	3.0 ± 1.0
pupae	6.8 ± 12.2	-	-	-	-
Tipulidae larvae	5.5 ± 2.1	3.0 ± 3.0	3.5 ± 1.9	3.0 ± 2.0	7.3 ± 0.6
Unidentified pupae	4.5 ± 9.0	-	-	-	
Planaria	0.2 ± 0.5	-	-	-	-
Hirudinea	-	-	-	0.3 ± 0.6	-
Oligochaeta	1.5 ± 1.3	41.7 ± 45.9	17.0 ± 15.1	13.3 ± 18.9	35.7 ± 26.8
Gastropoda: Limpet	-	-	0.2 ± 0.5	0.3 ± 0.6	-
Pelecypoda	-	-	0.8 ± 1.5	-	-
Arachnida: Hydracarina	0.2 ± 0.5	-	-	1.3 ± 2.3	-
Total	163.5 ± 72.4	122.7 ± 73.3	208.0 ± 91.6	115.7 ± 63.6	146.3 ± 33.1

* Expressed as mean numbers and standard deviations of invertebrates collected in four 0.093 m^2 Surber samples.

** Single application block - McCallum Brook - treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

double application block - Young's Brook - treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June, and again at 0600 to 0750 hrs on 7 June 1980.

Table 32. Ratios* of mean numbers of selected benthic organisms in Surber samples collected in May 1980 and May 1981. York County, N.B.

	Untreated Control	Single** Application Block	Double** Application Block	1.4 km downstream from double block	4.2 km downstream from double block
phemeroptera: Total	1.4	3.3	1.5	0.2	2.6
Baetidae	1.6	+	3.1	0.2	23.7
Ephemerellidae	2.0	4.9	0.8	0.1	1.0
Heptageniidae	1.0	1.3	0.5	0.2	0.8
Leptophlebiidae	7.5	-	0.8		1.0
lecoptera	3.1	35.0	1.9	0.7	1.7
richoptera: Total	2.4	1.8	7.6	0.4	1.2
Brachycentridae	0.8	+	-	-	-
Glossosomatidae	+	1.4	12.3	0.5	3.3
Hydropsychidae	4.0	3.4	+	0.2	1.4
Rhyacophilidae	3.3	1.1		-	0.7
oleoptera	+		1.0	0.2	+
iptera: Total	0.7	1.8	6.4	0.9	0.3
Athericidae larvae	0.4	2.7		2.6	-
Chironomidae larvae	0.4	1.5	12.1	1.0	0.2
Simuliidae larvae	1.2	2.7	0.2	0.04	2.5
Tipulidae larvae	1.4	0.8	0.7	0.3	0.8
ligochaeta	+	2.2	9.4	2.5	11.9
otal organisms	1.02	2.28	4.75	0.63	1.00

* Mean number in 21 May 1981 Surber samples
Mean number in 24-26 May 1980 Surber samples

** single application block - McCallum Brook - treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980

double application block - Young's Brook - treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June, and again at 0600 to 0750 hrs on 7 June 1980.

+ present in 1981 but not in 1980.

- present in 1980 but not in 1981.

blank space indicates not present in either year.

those in May 1980 but the taxanomic composition was altered to some extent. Large increases occurred in the density of Ephemeroptera: Baetidae and Oligochaeta, accompanied by substantial decreases in numbers of Trichoptera: Brachycentridae and Chironomidae.

During the one year postspray sampling period artificial substrates were placed in each of the sites, except the 4.2 km downstream station on Young's Brook, and collected on 1 June. Comparison of the benthic invertebrates in the artificial substrates on 1 June 1981 (Table 33) with prespray samples (Appendix III) showed that most organisms increased in number or were present in comparable densities on both sampling dates. Larger numbers were especially evident among Chironomidae larvae with increases of 77% in the control, 610% in the single block, 500% in the double block, and 549% in the 1.4 km downstream station. Reduced numbers in artificial substrates occurred in the double application block where Ephemeroptera nymphs declined by 45% and Plecoptera nymphs by 22%. At the 1.4 km downstream site, Ephemeroptera nymphs demonstrated a slight decline (15%), but Plecoptera nymphs were reduced by 67%.

Diversity indices were calculated for 1981 benthos samples obtained from both Surber samples and artificial substrates. All treated stations except the 4.2 km downstream site on Young's Brook demonstrated a reduction in diversity between the prespray and the one year postspray samples, with the greatest decline occurring in and 1.4 km below the double application block (Table 34).

Fish diet studies

Samples of resident fish collected in the same manner as those on 26-27 May 1980 were obtained at all sample sites on 20-21 May 1981. No 1+ Atlantic salmon were caught in the single application block. One plus salmon were also absent from the untreated control, as they had been in May of 1980. Condition coefficients determined for all fish obtained in May 1981 were higher than those for the comparable 1980 samples. Mean volumes of food organisms consumed per mm of fish in the 1981 samples were higher than the May 1980 values, except for 2+ salmon in the treatment blocks and brook trout in the untreated control. Contributions of various food organisms to the diets of resident fish in May 1981 are presented in Figure 32, Table 35 lists abbreviations used to denote food items in this figure, and complete stomach analysis results from 1981 are listed in Appendix IX.

Ephemeroptera nymphs were the most frequent food item found in the stomachs of all fish at all sites with the exception of brook trout in the control stream (Fig. 32). Ephemeropterans were especially prominent in the diets of fish in the double application block, while trichopterans were more abundant in the stomach contents of fish at the control than treated sites. Simuliidae utilization by fish in the double application block was lower than at the other sites, but fish in both treated blocks fed on Tipulidae larvae to a greater extent than in the untreated control.

Table 33. Benthic invertebrates* collected in permethrin application blocks**, York County, N.B., 1 June 1981

Sample date 1 June 1981	Control	Single application block	Double application block	1.4 km downstream from double block
Ephemeroptera: Total nymphs	58.0 ± 9.0	51.2 ± 16.7	61.8 ± 19.9	84.8 ± 30.2
Baetidae	11.4 ± 3.7	1.6 ± 0.5	2.6 ± 1.5	3.4 ± 3.6
Ephemerellidae	40.8 ± 7.5	28.2 ± 11.0	30.8 ± 11.7	51.0 ± 29.3
Heptageniidae	0.2		1.2 ± 1.5	3.6 ± 1.7
Leptophlebiidae	5.6 ± 2.4	21.4 ± 7.4	25.8 ± 6.0	26.8 ± 7.1
Odonata	0.2			0.2
Plecoptera: Total nymphs	256.0 ± 65.3	60.2 ± 24.9	45.6 ± 11.4	25.0 ± 7.3
Taeniopterygidae				
Leuctridae	202.4 ± 54.9	48.2 ± 22.8	25.2 ± 5.3	8.6 ± 4.6
Nemouridae	48.2 ± 41.5	7.8 ± 4.0	0.6 ± 0.8	0.6 ± 1.2
Pteronarcyidae	0.2			0.4 ± 0.5
Perlidae		0.2	0.6 ± 0.8	1.2 ± 1.2
Perlodidae		0.4 ± 0.8	5.4 ± 3.4	9.0 ± 4.0
Chloroperlidae	1.0 ± 0.9	3.6 ± 1.7	13.6 ± 3.1	5.2 ± 1.7
Trichoptera: Total larvae	16.2 ± 5.0	4.8 ± 3.0	20.0 ± 23.0	38.8 ± 27.6
Brachycentridae	4.0 ± 1.7			
Glossosomatidae		0.2	0.6 ± 0.5	
Hydropsychidae	3.6 ± 3.4	1.8 ± 1.3	1.6 ± 1.4	26.4 ± 21.0
Hydroptilidae	3.8 ± 1.6			0.4 ± 0.8
Lepidostomatidae	1.4 ± 2.8		3.4 ± 2.8	6.0 ± 2.5
Limnephilidae	1.8 ± 1.3	0.4 ± 0.5	1.0 ± 0.6	0.4 ± 0.5
Philopotamidae			1.0	0.6 ± 1.2
Polycentropodidae		2.4 ± 2.9	8.4 ± 9.7	4.6 ± 5.4
Psychomyiidae			3.8	
Rhyacophilidae	1.6 ± 1.4		0.2	0.2
Coleoptera: Elmidae	2.6 ± 3.7		0.8 ± 0.7	
Diptera: Total	280.0 ± 45.5	434.4 ± 179.3	763.0 ± 249.2	692.2 ± 328.5
Chironomidae L	153.0 ± 25.6	326.6 ± 168.3	585.8 ± 111.7	524.6 ± 147.8
Simuliidae L	85.2 ± 59.5	46.2 ± 35.5	137.6 ± 155.4	143.4 ± 256.0
Athericidae L	15.4 ± 2.7	10.0 ± 3.6	0.2	6.2 ± 1.8
Other	29.0 ± 6.9	34.4 ± 10.4	19.2 ± 3.5	18.0 ± 3.5
Hydracarina	123.6 ± 99.6	49.4 ± 18.6	36.8 ± 6.4	94.6 ± 15.6
Nematoda		0.4 ± 0.8		
Planaria	1.6 ± 1.6			0.8 ± 1.2
Oligochaeta	0.6 ± 0.8	1.2 ± 0.7	2.8 ± 2.0	0.8 ± 0.7
Totals	669.8 ± 83.8	601.4 ± 202.1	931.0 ± 281.4	937.2 ± 369.0

* Expressed as mean number and standard deviation of invertebrates collected in five artificial substrates.

** Single application block - McCallum Brook - treated with 17.5 g AI/ha permethrin at 1850 h on 3 June 1980.

Double application block - Young's Brook - treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June, and again at 0600 to 0750 h on 7 June 1980.

Table 34. Diversity indices and standard deviation of benthic invertebrates collected in Surber samples and artificial substrates in May 1980 and May-June 1981

	Surber samples		Artificial substrates	
	May 1980	May 1981	May 1980	June 1981
Control	2.60 ± 0.26	3.38 ± 0.14	2.5 ± 0.22	3.0 ± 0.18
McCallum Brook single application block	2.73 ± 0.37	2.62 ± 0.10	3.1 ± 0.09	2.4 ± 0.37
Young's Brook double application block	2.99 ± 0.34	2.30 ± 0.80	3.0 ± 0.44	1.8 ± 0.19
Young's Brook 1.4 km downstream	3.24 ± 0.20	2.63 ± 0.30	3.3 ± 0.20	2.1 ± 0.40
Young's Brook 4.2 km downstream	2.60 ± 0.46	3.14 ± 0.08	3.2 ± 0.18	-

The diet composition of 1+ salmon in the double application block was similar in the 1980 and 1981 samples with a heavy utilization of ephemeropterans, but the contribution of Plecoptera nymphs and Trichoptera larvae decreased in 1981. In the May 1981 samples, 2+ salmon in the control demonstrated an increased selection of Ephemeroptera and Trichoptera but less extensive feeding on Plecoptera, Diptera, and terrestrial arthropods compared to the 1980 prespray samples. In the diets of 2+ salmon collected in the single application block in 1981, the utilization of Plecoptera and Trichoptera decreased, Simuliidae increased, and Ephemeroptera remained unchanged. Stomach contents of 2+ salmon in the double application block demonstrated an increase in the selection of Ephemeroptera nymphs in 1981 and a corresponding decrease in feeding on aquatic Diptera larvae and terrestrial arthropods.

The main difference in the diet composition of brook trout from the control stream in May 1980 and May 1981 was a substantial increase in terrestrial arthropods (mainly Lepidoptera larvae) in 1981. Plecoptera nymphs were less abundant in 1981 while a decreased utilization of Chironomidae corresponded to increased feeding on Simuliidae, so that the overall contribution of dipterans was unchanged. Similar changes were found in the diets of brook trout in the single application block with increased selection of terrestrial Lepidoptera larvae and Simuliidae larvae, and decreased feeding on Plecoptera nymphs and Chironomidae larvae in 1981. The food item selection by brook trout in the double application block also changed between May 1980 and May 1981, with increases in terrestrial arthropods (primarily adult aquatic insects) and Ephemeroptera nymphs, and decreases in Plecoptera nymphs and Trichoptera larvae.

No extensive changes were observed in the diet compositon of sculpins between May 1980 and 1981. Sculpins in the control stream utilized Trichoptera larvae to a slightly greater extent but decreased their selection of Tipulidae and Chironomidae larvae in 1981. In the single application block, sculpins reduced their utilization of Ephemeroptera nymphs and fed more extensively on Plecoptera nymphs and Tipulidae and Chironomidae larvae. Little change was noted in the food item selection of sculpins in the double application block between May 1980 and May 1981.

Table 35. Abbreviations used to denote fish stomach contents in Figure 32

Misc. - miscellaneous aquatic invertebrates (2%)

Eph - Ephemeroptera nymphs

Ple - Plecoptera nymphs

Tri - Trichoptera larvae

Col - aquatic Coleoptera adults

Ath - Athericidae larvae

Chir - Chironomidae larvae

Sim - Simuliidae larvae

Tip - Tipulidae larvae

MD - Miscellaneous Diptera larvae (2%)

Up - Unidentified Diptera pupae

OL - Oligochaeta

TA - terrestrial arthropods

DISCUSSION

One year postspray sampling of macroinvertebrates in both the single application and double application blocks did not conclusively demonstrate extended or delayed effects of the permethrin applications causing reductions in standing crop. Surber samples, especially from the site 1.4 km downstream of the double application block, indicated reductions in some organisms but this was not substantiated by results from artificial substrates or fish diet analyses. The inherent limitations of assessing benthos densities with Surber samples are acknowledged (Needham and Usinger 1956; Chutter 1972; Meehan and Elliott 1974), and may have contributed to some of the apparent reductions. Although these data are not definitive, Surber and artificial substrate sample results suggest a slight depression in numbers of certain invertebrates (e.g., some ephemeropterans and plecopterans) in and 1.4 km below the double application block. The extent to which these reductions are the result of the permethrin applica-

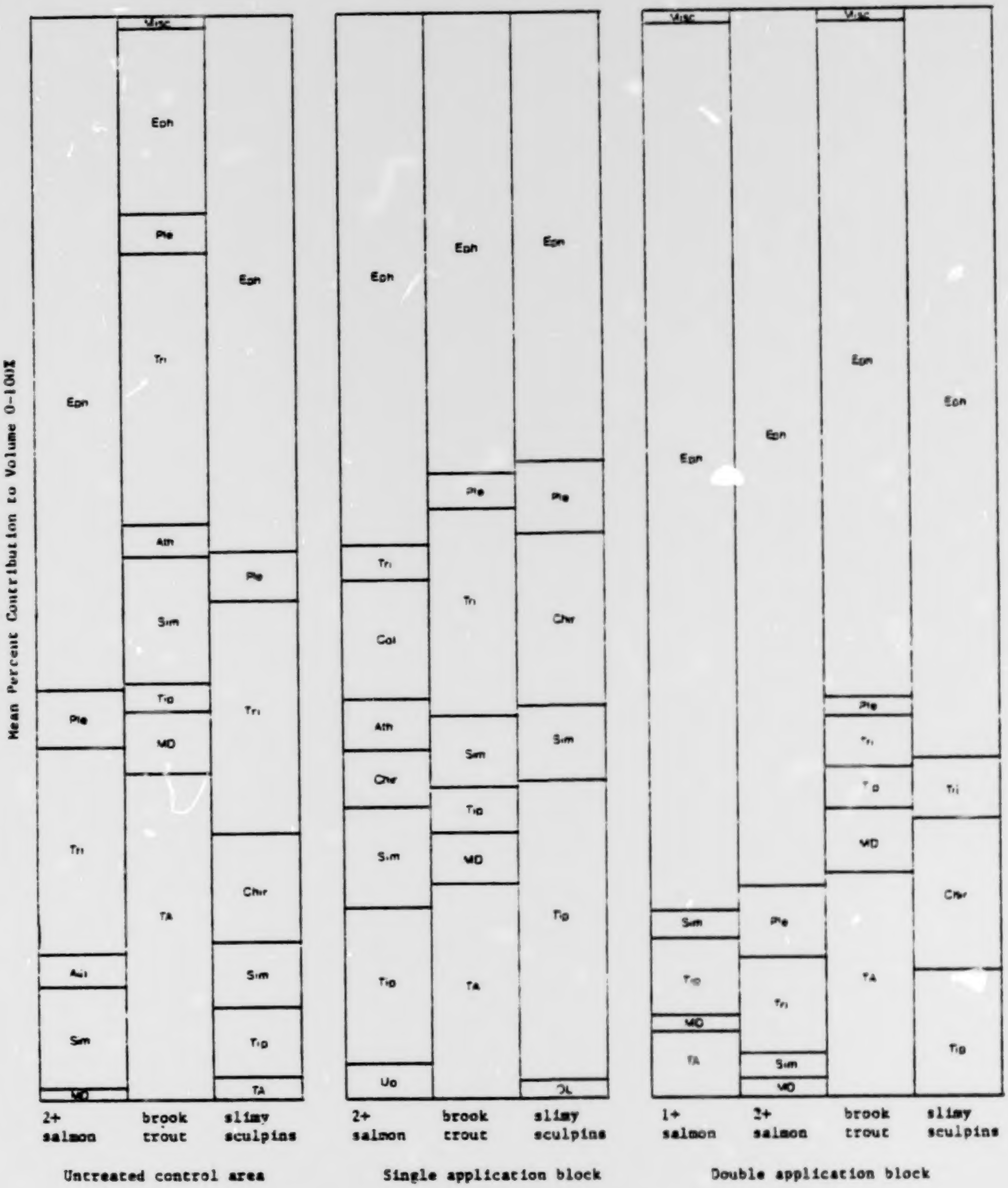

Figure 32. Contribution of various food organisms to stomach contents of native fish in Young's Brook, York County, N.B., 20-21 May 1981.

tions is not clear. Many documented studies of stream invertebrate ecology and distribution, including MacKay and Kalff (1969) and Allan (1975), demonstrate wide variations in benthic invertebrate populations, both spatially and temporally, within a stream. Consequently, many factors other than a permethrin impact may have influenced the discrepancies in standing crop estimates between May 1980 and May-June 1981. Because of the essentially complete recovery of benthos numbers by September 1980 (Section VI) and the results obtained from the 1981 sampling, it is apparent that no permethrin-induced impact, in terms of reduced overall invertebrate populations, persisted to the one year postspray sampling date.

However, some evidence of insecticide influence one year after the applications did exist at the station 1.4 km below the double application block. Although it was not possible to quantify, a massive increase in the amount of benthic algae was observed in May 1981, such that virtually the entire stream bed in the slower water areas was blanketed with filamentous algae. Similar reports of excessive algal growth following pesticide applications to streams or lakes have been documented (Hurlbert 1975; Hynes 1961; Filteau 1959; and Kingsbury 1975). Hurlbert (1975) concluded that this occurs where insecticide treatment or contamination reduces benthic herbivore populations and permits increases in algal growth. The site at which the algae bloom was observed in the present study had demonstrated substantial reductions in benthic invertebrates, especially Ephemeroptera and Plecoptera (Section VI), following the double permethrin application. Surber samples collected from this site in May 1981 contained small numbers of invertebrates and may have reflected a physical change in the substrate, induced by the algae growth, creating a localized area less suitable for invertebrate colonization. Artificial substrates, on the other hand, were collected from a nearby section of stream with a much faster flow rate and little evidence of excessive algal growth, and did not indicate depressed benthos numbers.

Evidence of a pesticide-induced disturbance of bottom fauna was observed at all treated stations on the one year postspray sampling date in the form of substantial increases in the numbers of Chironomidae larvae. Both Surber and artificial substrate samples from the treated streams contained large numbers of Chironomidae larvae relative to the chironomid populations in the control stream. This increase in chironomids a year or two after insecticide applications to streams has been previously reported by Moye and Luckmann (1964), Ide (1957, 1967), and Kreutzweiser and Kingsbury (1982). Hurlbert (1975) admits that conclusive evidence is lacking but suggests this phenomenon may result from either a decrease in predatory species or an increase in chironomid food supply or a combination of both. Further investigation of impact-related interactions of invertebrate species, and consequential population fluctuations, is desirable but well beyond the scope of this assessment.

Although most one year postspray benthos samples from the treated streams indicated a decreased invertebrate diversity, especially in and below the double application block, the calculated values probably reflected the marked increase in chironomids rather than major declines in the density and taxonomic composition of benthic invertebrates. Since the diversity index includes both total numbers of invertebrate groups present and their abundance relative to cohabiting groups, a major increase in any one taxon, such as Chironomidae, will decrease the diversity index values.

Results from stomach content analyses of resident fish one year after the permethrin applications indicated a normal opportunistic food item selection based on the available food resource. Fish diets included an abundance and variety of aquatic insects and terrestrial arthropods. Since the one year postspray benthos samples indicated no scarcity of invertebrates, a measurable reduction in feeding activity or a shift to alternate food sources of indigenous fish would not be expected.

XIII. OVERALL DISCUSSION AND CONCLUSIONS

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The aquatic impact studies on permethrin carried out in New Brunswick in 1980 differed from previous studies conducted by the Forest Pest Management Institute on this insecticide primarily in the nature of the aquatic system treated and the area of watershed treated. With the exception of the treatment of a 640 ha portion of a black spruce bog drainage system in 1979 (Kingsbury and Kreutzweiser 1980a), previous permethrin impact studies on stream systems in Canadian forest situations evaluated single swath treatments on portions of streams (Kingsbury 1976b; Kingsbury and Kreutzweiser 1979, 1980b). It is possible that such treatments underestimate the potential impact of the material applied on aquatic systems within sprayed blocks of forest, as spray coverage from a single swath may be limited and insecticide inputs through small feeder streams and terrestrial and foliar run-off may be far less than with block treatments. It is also possible that residues would persist for longer periods in streams running through treated blocks of forest where residual insecticide may be entering flowing waters from a wider area than occurs with single swath treatments.

The results of stream water residue and stream invertebrate sampling from the current study do not indicate that the effects of permethrin on the stream systems flowing through the size of blocks treated (600 ha) were substantially greater than effects previously documented with single swath treatments to streams. Peak permethrin residues measured in stream water were no higher than those measured after single swath treatments and declined to low levels just as quickly as has previously been reported (Kingsbury and Kreutzweiser 1979).

Measurable quantities of permethrin were found in stream water for somewhat longer periods of time after treatment than was the case in single swath treatment studies, but this primarily reflects a 20-fold increase in the analytical detection sensitivity over the period in which the studies were performed.

The magnitude and duration of impacts on stream invertebrates in the current study were similar to impacts previously found in streams treated at the same application rate by single swath treatments (Kingsbury and Kreutzweiser 1979, 1980b).

Although each individual permethrin application caused massive disturbances to aquatic invertebrate populations, the substantial additional impact of a second application to the same block in terms of furthering depression of benthic populations and extending the time period required for recovery of benthos numbers was once again clearly illustrated. The double application block in this study did, in fact, represent a fairly severe exposure scenario in that within 12 h of its initial treatment it was also subject to downstream effects resulting in a second peak in invertebrate drift after treatment of the upstream single application block. Despite this, the overall impact in the double application block in this study, in terms of benthos depression and altered fish diets, was not as severe or prolonged as impacts previously described after single applications of 35 or 70 g permethrin/ha to trout streams (Kingsbury and Kreutzweiser 1980b; Kreutzweiser and Kingsbury 1982).

The permethrin residue studies conducted in 1980 again demonstrated the very rapid disappearance of this material from forest streams after aerial applications. Permethrin and other pyrethroids are known to become tightly bound to soils due to their polarity characteristics (Graham-Bryce 1980; Kaufman et al. 1981), and movement of permethrin into sediments has been considered to be a major removal process in aquatic systems. Forest streams such as those studied are, however, very limited in the size of their organic sediment compartment because of constant transport of such material out of the system. Sediment residue studies carried out in forest streams in northern Ontario, Quebec, and the present study, have all suggested that residue accumulation in stream sediments is somewhat limited (Kingsbury and Kreutzweiser 1980a; Kreutzweiser 1982), and more limited than accumulation in forest pond sediments (Kingsbury and Kreutzweiser 1979; Kreutzweiser 1982).

Recent studies have shown that benthic insects and aquatic plants present in forest streams can accumulate substantial concentrations of organophosphorous insecticides. Concentrations of acephate in benthic insects in a small coastal British Columbia stream experimentally injected with a commercial formulation were higher than in either fish or sediments by roughly an order of magnitude (Green et al. 1981). Peak fenitrothion residues measured in aquatic plants and insects approached 10 µg/g dry weight (10 ppm) in forest streams in New Brunswick treated with mistblower applications simulating aerial spray deposits (Montreal Engineering Co. 1981). These levels were about 1,000 times higher than peak fenitrothion residues measured in the stream water, and are at least an order of magnitude higher than residue levels reported in fish from fenitrothion spray areas (Hatfield and Riche 1970; Lockhart et al. 1973; Kingsbury 1977). Rawn (1981) studied the fate and degradation of permethrin in a model aquatic ecosystem and found that although the hydrosoil (sediment) was the major sink for permethrin in his pondlike system, peak permethrin concentrations in fish were an order of magnitude higher and in an aquatic plant (duckweed) more than two orders of magnitude higher than in hydrosoil.

In light of the above, it is possible that in a fast flowing forest stream with little organic sediment, aquatic invertebrates and aquatic plants and algae adapted to flowing water may serve as major "sinks" of permethrin residues. Indirect support for this hypothesis, at least with respect to aquatic insects, is given by the massive invertebrate drift seen after each permethrin application and the large piles of insects (e.g., Fig. 22) observed on the stream bottom. The presence of permethrin in these organisms is attested to by their response, and their relative mass compared to the hydrosoil compartment in these streams seems substantial, at least on a subjective observational basis. Aquatic plants, primarily mosses (e.g., *Fontinalis* sp.), and filamentous algae were abundant in Young's Brook and may have served as another major permethrin sink. Large differences have been found in the extent to which various stream dwelling plants accumulate the organophosphorous insecticide fenitrothion (Montreal Engineering Co. 1981). This suggests that specific information on the permethrin accumulation potential of each type of aquatic plant contributing substantially to the vegetation compartment of the stream would be required to adequately assess its overall importance as a potential insecticide sink. Fish, although a fairly small component of the total biomass of stream systems, may constitute a small but significant sink for permethrin residues, particularly because of the probability that they will ingest fairly large quantities of permethrin present on or in aquatic insects.

The persistence, fate, and toxicological significance of permethrin residues in any of the biological or physical substrates present in a stream are likely to be quite different. Permethrin residues bound to organic sediments have been shown to maintain some toxicity to burrowing mayfly nymphs (Friesen 1981), but the absence of these types of sediments and associated invertebrates from most salmonid-bearing forest streams suggests these types of effects would not be of major importance in forestry situations. Permethrin residues on drifting invertebrates may lead to transport of residues out of sprayed areas, and possibly deposition of local concentrations of residues in pools where drifting organisms settle. Residues associated with aquatic plants may suppress grazing invertebrate populations remaining after initial impacts, or suppress recolonization of depopulated areas. The rather rapid and fairly complete (in terms of numbers at the family level) recovery of benthos populations observed suggests, however, that such effects, if present, were not of prolonged duration or impact.

The present study provided an opportunity to assess the potential for lethal impacts of permethrin on fish when applied under simulated forestry use conditions approaching a reasonable worst-case situation (e.g., other than accidents or misuse). A species (Atlantic salmon) known to be highly sensitive to permethrin (Table 2) was exposed to the material under test conditions (cold water, small body weight) known to contribute to the greatest potential for lethal effects on fish (Kumaraguru and Beamish 1981). In spite of this, no pesticide related mortality of salmon sac-fry held in upwelling boxes occurred. No mortality of native fish species was observed despite intensive sampling, and observation activities within the treated areas, and fish population censuses demonstrated substantial numbers of 0+ salmonids entered populations within the treated areas over the season. All of the above, coupled with prior evidence that fish mortality does not occur in forest streams treated with up to 70 g permethrin/ha (Kingsbury and Kreutzweiser 1979, 1980a and b), suggests that a safety factor towards fish exists when permethrin is applied to forest areas at 17.5 g/ha. If it is assumed that this safety factor has disappeared at an application rate of 140 g/ha, at which some fish mortality in a treated lake has been reported (Kingsbury 1976a), this factor is greater than 4 but less than 8. Although small, this magnitude of safety factor in application rate at which light but detectable fish mortality would begin to occur is no less than that for the organophosphate insecticide fenitrothion, which has been used very extensively for spruce budworm control in forests containing fish bearing streams for many years without causing fish mortality.

By contrast, it is abundantly clear from this and previously reported studies that no safety margin exists for lethal effects on a wide variety of aquatic invertebrates when permethrin is applied to forest streams at 17.5 g/ha. Permethrin-induced disturbances of benthic invertebrate communities at this dosage are severe and, apparently, inevitable with current formulations and application procedures.

Up until now secondary effects on native fish populations resulting from impacts on aquatic invertebrates have not been adequately evaluated or documented, aside from resultant changes in fish diets. This study has demonstrated (but not fully quantified or explained) that secondary effects on fish populations and their growth are likely to result from primary effects on fish food organisms associated with permethrin use as conceived for spruce budworm control in eastern Canadian forests. The effects which appear to be likely to occur are temporary reductions in fish growth rates in treated areas and movement of fish out of treated areas in response to decreased food availability. The nature and magnitude of these effects will likely be highly dependent on the geography of any treated stream systems (e.g., presence of untreated tributaries or upstream areas), and the density, species and age composition of resident fish. In the present study, population and growth reductions did not persist to the end of the season within the treated area, but it is possible that if a larger portion of the stream system had been treated these would have occurred.

It seems clear from efficacy studies done to date that effective large area spruce budworm control using permethrin applied by aircraft requires at least two applications of 17.5 g AI/ha (DeBoo 1980b; Zylstra and Obarymskyj 1981). If this treatment is likely to consistently produce severe impacts on aquatic invertebrate populations and measurable secondary effects on fish growth and populations, it is clearly not an acceptable treatment for use in forest areas containing fish-producing waters. Until some method of increasing permethrin's effectiveness at lower application rates or improving its selectivity is found, this treatment should only be considered appropriate for aerial use in situations where no such aquatic systems are present or where it can be demonstrated that they can be effectively buffered from the effects of treatment.

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APPENDIX I

Sampling and analysis procedures used in permethrin residue studies, New Brunswick field program, 1980.

WATER SAMPLING AND ANALYSIS

Collection

Water samples were collected by simultaneously immersing two 1 litre amber glass bottles into the water to a depth where the mouth of the bottle was 10 cm below the surface. Water was allowed to bubble into the bottles until they were entirely filled. Approximately 50 mL was decanted from each bottle and 50 mL of distilled in glass hexane was then added to each bottle. NB: The contents of each bottle were considered to be one half of the same sample. This two litre sample was then kept refrigerated until it could be extracted.

Extraction

Extraction was carried out by decanting 700 mL of the 2000 mL sample and extracting once with 100 mL distilled in glass hexane and twice with 50 mL hexane. The hexane extracts were combined and the water discarded. This extraction procedure was repeated with a second 700 mL aliquot and the final 600 mL aliquot. All hexane extracts were combined including the two 50 mL quantities added to the samples in the field. Both sample bottles and separatory funnels were washed twice with 50 mL hexane which was then added to the hexane extracts. The extracts so prepared were then refrigerated until analyzed.

Analysis

The hexane extracts were decanted into a 1 litre separatory funnel and any water which had been carried over from the extraction process was removed. The hexane was then passed through a filter containing anhydrous sodium sulfate. The hexane was then evaporated to dryness under reduced pressure at 40°C in a Buchi Rotary Evaporator. The evaporated residues were dissolved in 10 mL, distilled in glass hexane and analysed directly by Electron Capture detection after separation on a 5% OV-101 on Gas Chrom Q column at 245°C, quantifying against a range of standards.

Recovery Determination

Two litres of tap water were spiked with various concentrations of permethrin in methanol. The water was then extracted, dried and analysed as above and the concentration determined compared to the concentration added to yield percent recovery (95%).

Confirmation

The identity of extraneous residue was confirmed as permethrin if the component eluting at the same retention time (± 5%) on the non-isomer-resolving column listed above resolved into two peaks with retention times corresponding to the cis- and trans-isomers of permethrin using a 5% OV210 or 5% QF1 on Gas Chrom Q.

Operating Parameters:

Regular Analysis

Column : 5% OV or 3% OV 1 on Gas Chrom Q 100-120 mesh
100 cm x 4 mm LD
Oven Temp. : 245°C Isothermal
Inlet Temp. : 260°C
Outlet Temp. : 275 to 280°C
Detector Temp. : 300°C
Carrier Flow : 65 mL/min. Helium (6.5 on BROOKS
R-2-15 AAA ROTAMETER)
Attenuation : 16 x 10^2 depending on concentration
Background : 90 to 92% of full saturation of N;63
Current (ECD) : detector

Isomer Separation Determination

Column : 5% OV 210 or 5% QF-1 on Gas Chrom Q (100 - 120 mesh)
Other Parameters: As above

LITTER SAMPLING AND ANALYSIS

Collection

Litter samples were collected by cutting sections of forest floor litter 17.8 cm x 10 cm to a depth of 2.5 cm (using a Mini-Shipek Sediment Sampler as a template). Five such sections from an area of 10 square metres were collected and amalgamated as one sample for each site. The litter samples then were placed in polyethylene bags and frozen until analyzed.

Extraction

After the initial sample was mixed well by hand a 50 g subsample was taken and ground in a Sorval Omnimixer for 5 minutes in the presence of 50 g anhydrous sodium sulfate and 200 mL of solvent (160 mL hexane and 40 mL acetone). The homogenized macerate was then vacuum filtered through a No. 4 Whatman filter paper into an Erlenmeyer flask. The macerator container was then rinsed with acetone (2 x 50 mL) and these rinses were sucked through the previously filtered macerate. The filtrate was transferred to a 1000 mL separatory funnel and washed with 200 mL distilled water and 25 mL of 1M sodium sulfate, discarding the lower layer. Washing was then repeated with 150 mL water and 25 mL 1M sodium sulfate. The remaining organic layer was dried over 25 g of anhydrous sodium sulfate. A measured portion was then removed and evaporated to dryness under vacuum at 40°C on a Buchi Rotatory Evaporator and made up to a final volume of 10.0 mL with hexane.

Clean-up and analysis

An aliquot (2.0 mL) of extract was transferred to a freshly prepared Florisil column (activated florisil stored at 130°C prior to use as clean up media). This was allowed to percolate into the column at a rate of 1 mL per minute. The column was then washed and eluted as established by the elution patterns previously determined. Volume of the eluate was reduced to dryness and made up to a volume suitable for G.C. analysis. Analysis was conducted under conditions identical to that for the analysis of water extracts.

A typical elution pattern was to wash the column (5 g Florisil + 1 g anhydrous sodium sulfate under hexane) with 2 x 25 mL hexane after allowing the 2 mL aliquot to percolate into the column. The permethrin was then eluted with 5% diethyl ether in hexane. Permethrin typically elutes in the 75 to 175 mL range with the cis-isomer eluting first.

Recovery determination

To 50 g of litter was added 5 L of 0.1 ppm permethrin standard (10 g permethrin). This was extracted into 200 mL extracting solvent (2 parts acetone, 8 parts hexane) which was then filtered and washed with sodium sulfate solution and dried as described in *Extraction.* A 100 mL aliquot was taken and evaporated to 10 mL. Two mL of this was cleaned up on florisil and the permethrin fraction concentrated to 10 mL. Recovery was 82% at this level.

Recovery after spiking with 25 g permethrin was 85.6%.

Confirmation

As required.

Technique described in analysis of water extracts.

Operating Parameters

As described in *Water sampling and analysis.*

AQUATIC SEDIMENT SAMPLING AND ANALYSIS

Collection

Sediment samples were collected using an aluminum cup shaped dipper (5 cm diameter x 6.4 cm length) immersed on its longer edge into the sediment to a depth of 2.5 cm (half diameter). The dipper was advanced slowly until filled with sediment (twice length of dipper cup). The sediment was then placed in a 750 mL screw cap jar. Five such collections were made within a two square metre area at each site and amalgamated, in the one jar, as one sample. As much water as possible was drained off after all the material had settled and then the sample was frozen until analyzed. Each sample so collected weighed approximately 800 g and represented about 320 cm^2 centimetres of river bottom.

Extraction

The samples were allowed to thaw and equilibrate to room temperature; they were then thoroughly shaken, and allowed to settle. Any supernatant water was then decanted off. A 50 g aliquot was removed and homogenized, in the presence of 200 mL solvent (20% acetone, 80% hexane) and 50 g anhydrous sodium sulfate, for 5 minutes in a Sorval Omnimixer. The macerate was then vacuum filtered through a No. 4 Whatman filter paper. The homogenizer was rinsed with acetone (2 x 50 mL) and the rinses drawn through the previously filtered macerate. The filtrate was transferred to a 1000 mL separatory funnel and washed with 200 mL distilled water and 25 mL 1M sodium sulfate, discarding the lower layer. The organic layer was washed a second time with 150 mL water and 25 mL 1M sodium sulfate. The remaining organic layer was then dried over 25 g of anhydrous sodium sulfate.

A measured portion of the hexane solution was then evaporated to dryness at 40°C and made up to a volume of 10 mL with hexane.

Clean-up and analysis

An aliquot (2.0 mL) of the above extract solution was transferred to a freshly prepared Florisil column and allowed to percolate into the column at a rate of 1 mL/min. The column was then washed and the permethrin eluted according to elution patterns established previously. The volume of the eluate containing the permethrin was reduced to dryness and the residue taken up in 10 mL hexane (or other suitable volume) for G.C. analysis. Analyses were conducted under conditions identical to that described elsewhere for water and litter.

Recovery determination

To a 50 g sample of aquatic sediment, 10 g of permethrin was added. This was extracted according to the foregoing method using a 100 mL aliquot of the original 160 mL which was then concentrated to 10 mL, 2 mL of which was cleaned up on a Florisil column. Three recoveries were conducted and were found to be 114.7%, 116.8% and 127.4%.

Confirmation

As required, according to methodology indicated in *Water sampling and analysis*.

Operating parameters

As described in *Water sampling and confirmation analysis*

AQUATIC ORGANISM SAMPLING AND ANALYSIS-FISH, EELS AND CRAYFISH

Collection

Fish (trout, salmon, slimy sculpin, eels and crayfish) were collected by electro-seining techniques. These were sized, sexed and eviscerated. Individual fishes were separated by species and grouped according to their sizes to give a combined weight of 25 to 50 g per group and these were treated as individual samples. Individual fish which weighed in excess of 25 g were kept separate and treated as individual samples.

The samples were wrapped in clean unused aluminum foil, placed in sealed plastic bags and frozen until analyzed.

Analysis

Frozen fish samples were immersed in distilled water until they had thawed sufficiently to be easily separated. Sufficient whole fish were taken so that their combined weight was in excess of 25 g and these were extracted for analysis. (The number of fish comprising the initial sample and the number of fish comprising the extraction sample were noted for reference).

The whole fish selected above were macerated for 2 to 5 minutes in the presence of 150 mL solvent (40% acetone, 60% hexane) and 200 g anhydrous sodium sulfate. The homogenized macerate was then vacuum filtered through a No. 4 Whatman filter paper. The macerator was rinsed with the extracting solvent system (2 x 50 mL) and these rinses were passed through the filtered macerate. The filtrate was then transferred to round bottom flask and evaporated to dryness (oily layer). This residue was then dissolved in hexane and diluted with hexane to 10 mL. A 1 mL aliquot was then cleaned up on 5 g of silica gel according to elution patterns established for silica gel. The volume of eluant containing permethrin was reduced to dryness and the residues taken up in a volume of hexane suitable for G.C. analysis (2 mL). Analysis was then conducted under conditions identical to that described in *Water sampling and analysis*.

A typical elution pattern using silica gel was to first percolate 1 mL of the sample solution into the silica gel (5 g prepared in hexane). The silica gel was then washed with 15 mL of hexane and 9 mL of 5% diethyl ether in hexane. The permethrin was then eluted with 20 mL of 5% diethyl ether in hexane.

Fractosil was also used on occasion and required a decrease in the volume of the ether/hexane wash to 5 mL and a decrease in the eluant volume collected to 17 mL of 5% ether in hexane.

Florisil (5 g), to which a 1 mL aliquot of sample had been added, was washed with 25 mL hexane and 25 mL 5% ether in hexane. The permethrin was then eluted with 125 mL of 5% ether in hexane.

Silica gel clean-up was generally the method of choice but on occasion Fractosil was also used as a second column clean-up.

Recovery determination

Approximately 25 g of whole fish was spiked with 2 and 5 g and extracted as described above. A 1 mL aliquot was cleaned up and the eluate was concentrated to 2 mL and analysed. Recoveries of 73 and 81% were recorded for salmon, and 91 and 75 percent for trout.

Confirmation

As required according to methodology indicated in *Water sampling and analysis*.

Operating parameters

As described in *Water sampling and analysis*.

APPENDIX II

Organisms caught in drift nets set in Young's Brook watershed, May to August 1980.

Table 1. Invertebrates/m^3 in drift nets in the untreated control section of Young's Brook on the day of first application to spray blocks, 3 June 1980

Date	June 3, 1980									
Time	0515	0610	0710	0810	0910	1010	1313	1710	1905	2100
Replicates	1	1	1	1	1	1	1	1	1	1
Discharge through nets (l/sec)	8.12	8.12	8.12	8.12	24.36	8.12	8.12	8.12	8.12	8.12
Volume sampled (m^3)	21.92	21.92	21.92	21.92	43.84	21.94	21.94	21.94	21.94	21.94
Plecoptera	-	-	0.05	-	0.04	0.05	-	-	-	-
Leuctra spp.	-	-	-	-	0.02	0.05	-	-	-	-
Phasganophora capitata Pictet	-	-	-	-	-	-	-	-	-	-
Ephemeroptera	0.10	-	-	-	0.06	0.14	-	0.19	-	0.09
Ephemerella subgenus *Ephemerella*		-	-	-	0.02	0.09	-	0.05	-	0.09
E. subgen *Eurylophella*	-	-	-	-	0.02	-	-	-	-	-
Baetis spp.	0.05	-	-	-	0.02	0.05	-	0.14	-	-
Heptageniidae	0.05	-	-	-	-	-	-	-	-	-
Epeorus spp.	0.05	-	-	-	-	-	-	-	-	-
Trichoptera	0.32	0.37	0.05	0.05	0.14	0.36	-	0.14	0.23	0.18
Rhyacophilidae	-	-	-	-	-	-	-	0.05	-	-
Hydropsychidae	-	-	-	-	-	-	-	-	-	-
Diptera	3.06	8.39	1.65	0.59	2.17	1.65	1.19	3.20	4.51	1.91
Simuliidae	1.96	4.74	0.87	0.32	0.73	0.78	0.41	1.05	1.32	0.77
Chironomidae	1.05	2.74	0.78	0.27	1.42	0.82	0.78	2.10	3.19	1.14
Paleodipteron walkeri Ide	-	-	-	-	-	-	-	-	-	-
Odonata	-	-	-	-	-	-	-	-	-	-
Coleoptera	-	-	-	-	-	-	-	-	-	-
Total insects	3.38	8.76	1.75	0.64	2.41	2.20	1.19	3.53	4.74	2.18
Hydracarina	0.18	0.37	-	0.18	0.11	0.23	0.50	0.32	1.05	0.27
Oligochaeta	-	-	-	-	-	-	-	-	-	-
Planaria	-	-	-	-	-	-	-	-	-	-
Total Aquatics	3.56	9.13	1.75	0.82	2.52	2.43	1.69	3.85	5.79	2.45
Terrestrials	0.23	1.09	0.09	0.23	0.41	0.18	0.37	0.73	1.14	-
Total	3.79	10.22	1.84	1.05	2.93	2.61	2.06	4.58	6.93	2.45

Table 2. Invertebrates/m^3 in drift from McCallum Brook near outflow of single application block on day of application*, 3 June 1980

Date	June 3, 1980					
Time	0510	0900	1920	1936	2022	2115
Replicates	1	1	1	1	1	
Discharge through nets (l/sec)	45.80	45.80	45.80	45.80	45.80	45.80
Volume sampled (m^3)	41.22	41.22	13.74	13.74	13.74	41.22
Plecoptera	0.36	0.04	29.11	246.88	386.61	463.46
Leuctra spp.	0.34	0.02	3.49	214.27	386.61	400.59
Phasganophora capitata Pictet	-	-	-	-	-	-
Ephemeroptera	0.11	0.09	5.82	54.72	128.10	360.99
Ephemerella subgenus *Ephemerella*	-	0.02	-	3.49	-	24.84
E. subgen *Eurylophella*	0.02	0.02	-	-	4.66	26.40
Baetis spp.	0.02	0.05	-	29.11	30.28	189.42
Heptageniidae	0.02	-	1.16	1.16	32.61	31.05
Epeorus spp.	0.02	-	1.16	-	23.29	28.72
Trichoptera	0.26	0.05	-	2.33	18.64	41.92
Rhyacophilidae	-	-	-	-	2.33	-
Hydropsychidae	0.02	-	-	-	9.32	12.42
Diptera	3.03	1.70	1509.17	404.08	244.54	505.39
Simuliidae	1.94	0.90	1475.40	357.50	156.04	272.49
Chironomidae	1.02	0.78	2.33	12.81	34.93	196.41
Paleodipteron walkeri Ide	-	-	31.44	-	-	32.61
Odonata	-	-	-	-	-	-
Coleoptera	-	-	3.49	1.16	4.66	2.33
Total Insects	3.76	1.88	1547.59	709.17	782.55	1374.09
Copepod	-	0.02	-	-	-	-
Hydracarina	0.02	0.07	-	3.49	4.66	8.54
Oligochaeta	-	-	-	-	-	-
Planaria	-	-	-	-	-	-
Total Aquatics	3.78	1.97	1547.59	712.66	787.21	1382.63
Terrestrials	0.61	1.04	18.63	10.40	6.99	-
Total	4.39	3.01	1566.22	723.14	794.20	1382.63

* 17.5 g permethrin AI/ha between 1850 h and 2035 h.

Table 3. Invertebrates/m^3 in drift from Young's Brook at outflow of double application block on day of first application[a], 3 June 1980

Date	June 3, 1980										
Time	0501	0629	0729	0829	0900	1029	1329	1729	1855	1955	2110
Replicates	1	1	1	1	4	1	1	1	1	1	1
Discharge through nets (l/sec)	24.52	25.23	25.23	25.23	25.23	33.61	25.23	25.23	25.53	25.23	25.23
Volume sampled (m^3)	22.07	22.07	22.07	7.36	10.11	7.36	14.71	22.07	22.07	14.71	22.07
Plecoptera	-	-	550.97	1645.79	744.56	610.26	405.65	185.23	136.80	224.07	159.50
Leuctra spp.	-	-	405.98	741.30	553.66	461.82	361.12	154.42	116.00	193.61	118.17
Phasganophora capitata Pictet	-	-	8.70	19.57	97.43	0.07	33.65	1.09	1.50	-	9.43
Ephemeroptera	0.41	0.05	156.60	458.70	622.57	771.88	313.53	197.19	134.85	267.57	65.26
Ephemerella subgenus *Ephemerella*	0.14	-	2.90	110.87	91.88	227.04	141.40	23.92	24.65	41.33	20.30
E. subgen *Eurylophella*	-	-	8.70	21.74	49.90	348.23	17.40	55.46	44.95	65.26	7.98
Baetis spp.	0.09	0.05	78.30	130.43	113.27	34.78	17.47	15.59	14.50	39.16	8.70
Heptageniidae	-	-	14.50	115.21	84.75	34.78	10.88	18.04	10.15	-	3.63
Epeorus spp.	-	-	-	63.04	39.60	17.39	4.35	3.63	-	-	0.73
Trichoptera	0.05	0.05	66.70	856.52	645.55	787.78	204.49	0.36	56.55	130.53	49.30
Rhyacophilidae	-	-	2.90	10.87	11.88	-	6.53	-	1.43	2.18	0.73
Hydropsychidae	-	-	5.80	54.35	300.20	748.51	156.63	0.36	42.05	104.42	31.17
Diptera	1.91	0.24	463.98	1047.83	742.98	632.07	600.41	265.75	197.14	450.31	332.04
Simuliidae	1.41	0.14	324.79	321.74	175.05	143.48	152.28	79.75	42.05	121.82	47.85
Chironomidae	0.45	0.05	121.79	665.22	521.98	436.14	393.75	156.59	126.14	248.00	247.94
Paleodipteron walkeri Ide	-	-	-	-	17.43	22.01	28.28	17.81	17.40	63.09	26.10
Odonata	-	-	-	-	-	-	-	-	-	-	-
Coleoptera	-	-	2.90	21.74	3.17	4.35	2.18	0.36	-	-	-
Sialis	-	-	-	-	1.58	-	-	-	-	-	-
Total Insects	2.37	0.34	1241.15	4030.58	2761.99	2806.34	1526.26	648.89	525.34	1072.48	606.10
Copepoda	-	-	-	-	-	-	-	-	-	-	-
Hydracarina	0.14	-	23.20	80.44	59.41	60.87	2.18	5.44	14.50	6.53	15.95
Oligochaeta	-	-	-	-	-	-	-	0.36	-	-	-
Planaria	-	-	-	-	-	-	-	-	-	-	-
Total Aquatics	2.51	0.34	1264.35	4111.02	2819.82	2867.21	1528.44	654.69	539.84	1079.01	622.05
Terrestrials	0.14	0.09	5.80	-	22.97	26.09	13.05	10.87	13.05	47.86	5.80
Total	2.65	0.43	1270.15	4111.02	2842.79	2893.30	1541.49	665.56	552.89	1126.87	627.85

[a] 17.5 g permethrin AI/ha between 0618 h and 0805 h.

Table 4. Invertebrates/m^3 in drift nets in the untreated control section of Young 's Brook on the day of second application to double application block, 7 June 1980

Date	June 7, 1980						
Time	0510	0550	0650	0850	0950	1250	1750
Replicates	1	1	1	4	1	1	1
Discharge through nets (l/sec)	25.28	25.28	23.64	26.52	22.99	23.08	22.71
Volume sampled (m^3)	29.09	29.09	21.28	47.74	20.69	20.77	20.44
Plecoptera	0.07	0.07	0.05	0.02	-	0.05	0.10
Leuctra spp.	0.07	0.07	0.05	-	-	0.05	0.10
Phasganophora capitata Pictet	-	-	-	-	-	-	-
Ephemeroptera	0.17	-	0.05	0.06	-	-	-
Ephemerella subgenus *Ephemerella*	-	-	-	0.02	-	-	-
E. subgen *Eurylophella*	-	-	-	-	-	-	-
Baetis spp.	-	-	-	0.02	-	-	-
Heptageniidae	-	-	-	-	-	-	-
Epeorus spp.	-	-	-	-	-	-	-
Trichoptera	0.07	0.03	0.05	0.04	0.05	-	0.05
Rhyacophilidae	-	-	-	-	-	-	-
Hydropsychidae	-	-	-	-	-	-	-
Diptera	2.40	0.86	1.51	1.66	1.93	1.54	1.42
Simuliidae	1.58	0.55	1.18	0.55	0.87	0.82	0.83
Chironomidae	0.79	0.28	0.28	1.09	1.06	0.72	0.59
Paleodipteron walkeri Ide	-	-	-	-	-	-	-
Odonata	-	-	-	-	-	-	-
Coleoptera	-	-	-	-	-	-	-
Total Insects	2.71	0.96	1.66	1.78	1.98	1.59	1.57
Hydracarina	-	-	0.14	0.11	0.05	0.58	0.39
Oligochaeta	-	-	-	-	-	-	-
Planaria	-	-	-	-	-	-	-
Total Aquatics	2.71	0.96	1.80	1.89	2.03	2.17	1.96
Terrestrials	0.28	0.07	0.24	0.52	0.29	0.39	0.05
Total	2.99	1.03	2.04	2.41	2.32	2.56	2.01

Table 5. Invertebrates/m^3 in drift from Young's Brook at outflow from double application block on day of second application*, 7 June 1980

Date	June 7, 1980							
Time	0456	0556	0656	0756	0900	0956	1256	1700
Replicates	1	1	1	1	3	1	1	1
Discharge through nets (l/sec)	23.48	23.46	23.46	23.46	24.56	23.46	23.46	23.46
Volume sampled (m^3)	21.12	21.12	7.04	7.04	22.11	7.04	22.12	21.12
Plecoptera	2.51	75.00	248.72	557.39	212.30	310.51	388.45	70.43
Leuctra spp.	1.52	58.33	184.80	443.32	182.44	273.72	363.78	60.60
Phasganophora capitata Pictet	0.99	-	0.57	0.43	5.84	9.52	15.58	1.52
Ephemeroptera	2.76	113.63	124.74	655.97	337.05	669.47	366.90	26.52
Ephemerella subgenus *Ephemerella*	0.81	6.06	5.97	53.69	26.15	25.14	30.30	15.91
E. subgen *Eurylophella*	0.10	14.39	13.07	197.73	118.87	309.38	236.36	1.52
Baetis spp.	0.47	-	1.14	4.35	7.24	-	-	-
Heptageniidae	0.05	3.03	3.14	13.64	11.58	20.46	12.17	2.27
Epeorus spp.	-	-	-	4.55	-	-	-	-
Trichoptera	2.66	3.03	18.75	52.41	10.20	34.24	15.13	9.85
Rhyacophilidae	-	-	1.14	-	0.07	-	-	-
Hydropsychidae	1.71	1.52	14.06	43.18	7.96	20.60	6.06	-
Diptera	21.20	143.94	174.16	1118.33	400.19	612.93	361.03	189.40
Simuliidae	4.59	4.55	22.87	38.64	7.29	21.73	12.12	0.76
Chironomidae	14.06	106.06	115.06	929.69	302.76	518.75	300.43	120.46
Palaeodipteron walkeri Ide	0.99	-	17.05	15.91	5.07	2.42	-	-
Odonata	-	-	-	-	0.07	-	-	-
Coleoptera	-	-	2.27	0.14	0.91	2.70	3.08	1.52
Total Insects	29.13	335.60	568.64	2384.24	960.72	1629.85	1134.61	297.74
Copepoda	-	-	-	-	-	2.56	-	-
Hydracarina	0.19	24.24	29.12	162.62	45.07	60.23	30.45	30.30
Oligochaeta	-	-	-	-	-	0.14	0.05	-
Planaria	-	-	-	-	-	-	-	-
Total Aquatics	29.32	359.84	597.76	2546.86	1005.79	1692.78	1165.11	323.04
Terrestrials	1.09	1.71	3.55	27.42	1.45	11.79	42.52	1.52
Total	30.41	361.55	601.31	2574.28	1007.24	1704.57	1207.63	329.56

* 17.5 g permethrin AI/ha between 0600 h and 0750 h.

APPENDIX III

Aquatic invertebrates collected from rock ball artificial substrate samplers set in Young's Brook Watershed, May to October 1980.

Table 1. Aquatic invertebrates collected from rock bails (mean ± S.D. n = 5), in upstream control station, Young's Brook York County, New Brunswick, 27 May to 20 October 1980

Date	27 May	5 June	10 June	8 July	19 Aug.	20 Oct.
Ephemeroptera - Total nymphs	11.0 ± 6.0	25.0 ± 10.1	23.8 ± 1.9	12.8 ± 6.5	30.4 ± 10.2	97.6 ± 39.8
Baetidae	1.6 ± 1.1	8.4 ± 7.8	4.8 ± 2.3	1.6 ± 1.1	1.0 ± 1.2	25.6 ± 10.3
Ephemerellidae	8.2 ± 4.8	13.0 ± 5.1	11.4 ± 3.1	9.2 ± 6.0	22.2 ± 12.3	68.2 ± 34.4
Heptageniidae	0.2 ± 0.4	0.4 ± 0.5	0.4 ± 0.5	0.6 ± 0.5		0.6 ± 0.5
Leptophlebiidae	1.0 ± 1.2	3.2 ± 2.3	7.2 ± 1.5	1.2 ± 1.1	7.2 ± 8.3	3.0 ± 3.3
Plecoptera - Total nymphs	95.4 ± 41.0	65.2 ± 29.7	99.0 ± 35.1	118.2 ± 48.2	76.0 ± 27.6	229.0 ± 50.2
Taeniopterygidae						5.6 ± 5.4
Leuctridae	90.8 ± 41.5	58.2 ± 29.6	93.4 ± 32.4	110.6 ± 49.5	70.4 ± 28.7	214.4 ± 48.8
Nemouridae	2.6 ± 2.1	5.8 ± 4.9	3.6 ± 5.0	5.6 ± 3.9	0.4 ± 0.8	2.4 ± 3.2
Pteronarcyidae	0.4 ± 0.8	0.2 ± 0.4	0.6 ± 0.9	0.2 ± 0.4	0.8 ± 1.3	0.6 ± 0.5
Perlidae		0.4 ± 0.5				
Perlodidae	1.0 ± 0.7	0.2 ± 0.4			1.0 ± 1.2	2.8 ± 1.6
Chloroperlidae	0.6 ± 0.9	0.4 ± 0.5	1.4 ± 1.5	1.8 ± 0.8	3.4 ± 4.9	3.2 ± 5.1
Trichoptera - Total larvae	4.6 ± 3.6	10.4 ± 12.1	5.0 ± 3.2	1.4 ± 1.7	4.6 ± 0.5	79.8 ± 44.4
Polycentropodidae					0.6 ± 0.9	0.6 ± 0.9
Rhyacophilidae	0.2 ± 0.4	0.2 ± 0.4			2.2 ± 0.8	1.6 ± 1.9
Hydropsychidae	1.0 ± 1.0	2.2 ± 1.0	1.0 ± 1.2	0.2 ± 0.4	1.2 ± 0.8	5.8 ± 6.7
Lepidostomatidae	1.0 ± 1.2	0.6 ± 0.5	0.4 ± 0.8		1.2 ± 0.8	34.0 ± 38.2
Brachycentridae	2.0 ± 2.9	9.2 ± 14.6	3.0 ± 2.8	0.6 ± 0.5	0.2 ± 0.4	33.8 ± 24.9
Hydroptilidae			0.2 ± 0.4	0.6 ± 0.9		3.8 ± 5.8
Limnephilidae	0.4 ± 0.5	0.2 ± 0.4	0.4 ± 0.5			0.2 ± 0.4
Odonata		1.2 ± 1.3	0.2 ± 0.4	0.2 ± 0.4		
Megaloptera: Sialidae						
Coleoptera						
Elmidae	0.6 ± 0.9		0.2 ± 0.4		1.6 ± 1.1	2.0 ± 1.4
Diptera						
Chironomidae	86.6 ± 34.3	252.8 ± 139.0	171.6 ± 80.7	196.2 ± 68.8	120.6 ± 48.1	69.6 ± 22.7
Simuliidae	13.0 ± 7.3	69.0 ± 45.5	20.4 ± 17.0	7.2 ± 12.8	31.2 ± 41.6	5.0 ± 5.3
Athericidae	36.0 ± 14.5	37.8 ± 7.8	40.8 ± 16.5	32.0 ± 6.0	31.8 ± 18.8	17.0 ± 5.6
Other	3.0 ± 2.4	7.0 ± 3.9	5.6 ± 2.3	8.8 ± 6.6	26.8 ± 15.2	5.8 ± 2.6
Hydracarina	28.6 ± 22.0	29.0 ± 12.7	45.8 ± 29.9	28.0 ± 15.3	24.2 ± 17.6	9.4 ± 7.8
Nematoda				0.4 ± 0.5		0.6 ± 0.5
Planaria	0.6 ± 0.5		0.6 ± 0.9		0.6 ± 0.9	1.6 ± 2.5
Oligochaeta	0.4 ± 0.8	0.6 ± 0.5	0.8 ± 1.3	2.4 ± 1.9	1.2 ± 1.3	0.4 ± 0.5
Totals	279.5 ± 102.3	500.0 ± 160.9	413.8 ± 101.2	408.2 ± 126.1	349.8 ± 104.2	317.6 ± 103.7
Diversity index	2.5 ± 0.22	2.4 ± 0.46	2.5 ± 0.16	2.2 ± 0.18	2.8 ± 0.32	2.9 ± 0.27

Table 2. Aquatic invertebrates collected from rock balls (mean ± S.D. n = 5), in single application block*, McCallum Brook, York County, New Brunswick, 27 May to 20 October 1980

Date	27 May	5 June	10 June	8 July	19 Aug.	20 Oct.
Days before or after application	-7	+2	+7	+35	+77	+136
Ephemeroptera - Total nymphs	47.2 ± 6.4	24.2 ± 9.8	32.2 ± 20.7	8.6 ± 5.5	17.0 ± 13.6	122.4 ± 38.9
Baetidae	3.8 ± 3.3	0.6 ± 0.9	0.2 ± 0.4	1.6 ± 2.3	2.2 ± 2.8	35.8 ± 24.4
Ephemerellidae	25.8 ± 6.8	17.4 ± 7.8	23.8 ± 17.8	2.4 ± 1.8	5.6 ± 5.7	31.0 ± 10.1
Heptageniidae	0.6 ± 0.5	0.6 ± 0.9		0.2 ± 0.4		0.6 ± 0.5
Leptophlebiidae	17.0 ± 3.2	5.6 ± 2.4	8.2 ± 6.5	4.6 ± 6.1	9.2 ± 8.0	55.0 ± 9.4
Plecoptera - Total nymphs	51.6 ± 22.0	17.0 ± 13.5	22.6 ± 6.4	30.0 ± 25.2	28.8 ± 26.8	171.0 ± 53.7
Taeniopterygidae						7.6 ± 4.2
Leuctridae	23.4 ± 21.3	14.0 ± 13.4	19.8 ± 4.4	26.6 ± 23.9	21.6 ± 22.4	160.4 ± 50.8
Nemouridae	3.4 ± 3.0	1.1 ± 1.1	1.4 ± 1.5	2.0 ± 0.7	5.8 ± 9.7	1.8 ± 1.3
Pteronarcyidae	1.2 ± 1.8	0.2 ± 0.4	0.8 ± 1.1			0.2 ± 0.4
Perlodidae	7.2 ± 2.5	0.4 ± 0.5			0.6 ± 0.9	1.2 ± 1.3
Chloroperlidae	1.2 ± 1.3	1.2 ± 0.4	0.6 ± 0.5	1.4 ± 2.2	0.8 ± 1.6	4.4 ± 4.7
Unidentified	0.2 ± 0.4					
Trichoptera - Total larvae	3.0 ± 2.1	2.6 ± 2.4	1.6 ± 1.3	0.4 ± 0.5	5.8 ± 5.2	38.4 ± 21.3
Polycentropodidae				0.4 ± 0.5	0.2 ± 0.4	0.4 ± 0.5
Rhyacophilidae	0.4 ± 0.5	0.4 ± 0.8			0.2 ± 0.4	
Hydropsychidae	1.2 ± 0.4	0.8 ± 1.3	0.6 ± 0.5		3.6 ± 4.8	6.2 ± 3.5
Lepidostomatidae	0.6 ± 1.3	0.4 ± 0.5	0.8 ± 1.1		1.6 ± 1.8	30.8 ± 21.1
Brachycentridae	0.2 ± 0.4	0.4 ± 0.8				1.0 ± 0.7
Odontoceridae		0.2 ± 0.4				
Hydroptilidae			0.2 ± 0.4			
Glossosomatidae	0.2 ± 0.4	0.2 ± 0.4				
Limnephilidae	0.4 ± 0.5	0.2 ± 0.4			0.2 ± 0.4	
Odonata	0.2 ± 0.4		0.2 ± 0.4			
Diptera						
Chironomidae	46.0 ± 7.1	63.0 ± 30.4	68.2 ± 24.7	108.0 ± 27.5	107.8 ± 78.1	43.2 ± 22.7
Simuliidae	2.2 ± 2.9	12.8 ± 6.5	6.6 ± 4.0	7.0 ± 12.5	4.4 ± 5.1	2.0 ± 2.3
Athericidae	16.0 ± 3.7	19.2 ± 6.6	16.6 ± 3.9	23.6 ± 12.1	37.0 ± 8.3	11.6 ± 6.4
Other	2.8 ± 2.3	3.8 ± 3.1	2.6 ± 2.4	4.0 ± 1.2	37.0 ± 50.9	14.4 ± 17.3
Hydracarina	17.8 ± 10.1	19.0 ± 4.8	12.6 ± 7.2	22.6 ± 19.2	21.8 ± 4.9	11.0 ± 6.2
Nematoda	0.4 ± 0.5			0.8 ± 0.8	0.2 ± 0.4	1.0 ± 1.7
Planaria		0.2 ± 0.4	0.2 ± 0.4	0.4 ± 0.8	0.6 ± 0.5	1.6 ± 1.1
Oligochaeta	0.2 ± 0.4	0.4 ± 0.5		2.4 ± 2.3	3.8 ± 3.0	1.2 ± 0.8
Totals	172.4 ± 36.8	162.2 ± 31.6	163.4 ± 38.6	208.0 ± 55.8	264.2 ± 120.2	422.3 ± 69.3
Diversity Index	3.1 ± 0.09	2.8 ± 0.23	2.6 ± 0.36	2.1 ± 0.23	2.6 ± 0.38	3.0 ± 0.43

* treated with 17.5 g AI/ha permethrin at 1850 h on 3 June 1980.

Table 3. Aquatic invertebrates collected from rock bails (mean ± S.D. n = 5), in double application block*, Young's Brook, York County, New Brunswick, 27 May to 20 October 1980

Date Days before or after first (second) application	27 May -7(-11)	5 June +2(-2)	10 June +7(+3)	8 July +35(+31)	19 Aug. +77(+73)	20 Oct. +136(+132)
Ephemeroptera - Total nymphs	111.8 ± 58.3	41.2 ± 24.4	7.2 ± 1.9	8.4 ± 7.9	9.6 ± 2.2	81.6 ± 30.5
Baetidae	12.8 ± 8.0	0.8 ± 0.8		0.6 ± 0.5	1.0 ± 1.7	31.0 ± 13.4
Ephemerellidae	62.4 ± 34.5	14.0 ± 9.3	4.4 ± 1.7	2.0 ± 2.9	5.6 ± 3.6	12.5 ± 10.5
Heptageniidae	1.8 ± 2.5					0.2 ± 0.4
Leptophlebiidae	34.2 ± 16.9	26.2 ± 15.1	2.8 ± 1.7	5.8 ± 5.0	3.0 ± 1.6	37.8 ± 15.0
Plecoptera - Total nymphs	58.6 ± 16.5	13.2 ± 5.2	7.0 ± 3.2	16.6 ± 3.6	33.8 ± 19.2	84.6 ± 31.2
Taeniopterygidae					0.2 ± 0.4	7.2 ± 4.3
Leuctridae	16.6 ± 16.2	7.6 ± 3.2	3.8 ± 1.9	8.4 ± 4.7	18.8 ± 14.6	61.2 ± 24.7
Nemouridae	2.0 ± 2.3				0.8 ± 1.8	
Pteronarcyidae	0.6 ± 0.9		0.2 ± 0.4	0.6 ± 0.9	0.2 ± 0.4	0.6 ± 0.9
Perlidae	8.2 ± 4.3	1.8 ± 1.1	1.0 ± 1.4	3.0 ± 3.9		
Perlodidae	16.6 ± 8.3	1.2 ± 1.6	0.2 ± 0.4		11.0 ± 6.2	6.0 ± 3.0
Chloroperlidae	13.8 ± 7.6	2.6 ± 2.2	1.8 ± 1.8	4.6 ± 5.0	2.8 ± 3.8	9.6 ± 5.8
Unidentified	0.8 ± 1.8					
Trichoptera - Total larvae	9.2 ± 7.8	6.0 ± 2.3	3.0 ± 1.9	4.5 ± 2.6	12.0 ± 12.4	35.0 ± 12.1
Polycentropodidae				2.6 ± 3.7	1.2 ± 2.7	5.4 ± 3.7
Rhyacophilidae	1.0 ± 0.7	0.2 ± 0.4			1.0 ± 1.0	1.2 ± 1.3
Hydropsychidae	4.4 ± 4.8	1.4 ± 1.7	0.2 ± 0.4		7.2 ± 7.4	10.8 ± 5.2
Lepidostomatidae	3.0 ± 3.1	3.4 ± 2.8	2.8 ± 1.8	0.2 ± 0.4	1.8 ± 2.3	16.8 ± 5.9
Brachycentridae	0.8 ± 1.3	0.2 ± 0.4		0.4 ± 0.8		0.2 ± 0.4
Odontoceridae		0.4 ± 0.8			0.2 ± 0.4	
Philopotamidae				0.4 ± 0.5	0.4 ± 0.8	
Hydroptilidae						0.4 ± 0.5
Glossosomatidae		0.4 ± 0.5	0.4 ± 0.5			0.2 ± 0.4
Limnephilidae					0.2 ± 0.4	
Odonata					0.2 ± 0.4	
Megaloptera: Sialidae		0.2 ± 0.4			0.2 ± 0.4	
Coleoptera: Elmidae	0.4 ± 0.5	0.4 ± 0.5	0.4 ± 0.5	0.2 ± 0.4	0.4 ± 0.5	
Diptera						
Chironomidae	97.8 ± 90.1	73.4 ± 34.5	30.8 ± 11.2	225.4 ± 76.8	226.6 ± 166.6	64.0 ± 24.2
Simuliidae	131.4 ± 180.4	2.6 ± 2.2		1.2 ± 1.6	8.6 ± 14.8	5.6 ± 4.1
Athericidae	4.8 ± 2.2	2.4 ± 2.1	1.6 ± 1.1	1.2 ± 0.8	5.2 ± 7.3	0.8 ± 1.3
Other	2.8 ± 1.1	5.6 ± 4.4	2.8 ± 1.3	5.6 ± 2.1	32.3 ± 32.4	4.6 ± 3.2
Hydracarina	13.2 ± 8.6	37.2 ± 25.3	32.6 ± 37.3	43.4 ± 22.0	21.4 ± 12.4	4.2 ± 3.7
Nematoda	0.4 ± 0.9		0.2 ± 0.4	0.6 ± 0.9	0.2 ± 0.4	3.2 ± 4.1
Planaria		0.2 ± 0.4	0.2 ± 0.4	0.6 ± 0.5		0.4 ± 0.5
Oligochaeta	0.8 ± 0.8	1.2 ± 2.2	1.4 ± 1.7	1.4 ± 2.2	1.4 ± 1.7	3.8 ± 1.6
Totals	431.2 ± 322.8	183.6 ± 58.8	87.6 ± 32.8	308.4 ± 71.0	338.8 ± 225.6	287.8 ± 77.1
Diversity Index	3.0 ± 0.44	2.7 ± 0.32	2.4 ± 0.60	1.5 ± 0.44	2.2 ± 0.45	3.3 ± 0.07

* treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 h on 7 June 1980.

Table 4. Aquatic invertebrates collected from rock baits (mean ± S.D. n = 5), 1.4 km below double application block*, Young's Brook, York County, New Brunswick, 27 May to 20 October 1980

Date	27 May	5 June	10 June	8 July	19 Aug.
Days before or after first (second) application	-7(-11)	+2(-2)	+7(+3)	+35(+31)	+77(+73)
Ephemeroptera - Total nymphs	99.4 ± 65.7	47.5 ± 3.5	19.6 ± 4.6	8.8 ± 2.9	17.4 ± 12.5
Baetidae	5.6 ± 5.6	0.4 ± 0.5	0.4 ± 0.8		0.8 ± 1.3
Ephemerellidae	52.0 ± 49.7	21.0 ± 6.7	11.0 ± 3.4	2.8 ± 1.6	11.6 ± 9.6
Heptageniidae	3.2 ± 3.0	2.0 ± 1.9	0.2 ± 0.4		1.0 ± 1.2
Leptophlebiidae	38.6 ± 17.0	24.0 ± 10.6	8.0 ± 1.9	5.8 ± 2.3	4.0 ± 3.4
Plecoptera - Total nymphs	75.0 ± 12.3	20.4 ± 6.6	8.8 ± 2.4	23.2 ± 14.6	30.2 ± 3.3
Taeniopterygidae		0.2 ± 0.4			1.2 ± 1.8
Leuctridae	7.2 ± 6.3	8.4 ± 8.3	3.2 ± 2.2	6.6 ± 4.7	10.8 ± 4.3
Nemouridae	2.2 ± 2.6				
Pteronarcyidae		0.2 ± 0.4	0.2 ± 0.4	2.2 ± 1.6	0.2 ± 1.4
Perlidae	16.8 ± 5.4	8.0 ± 2.9	3.8 ± 2.2	13.4 ± 10.0	1.2 ± 1.6
Perlodidae	33.6 ± 5.7	0.8 ± 0.8			1.8 ± 3.0
Chloroperlidae	15.2 ± 7.0	2.8 ± 0.8	1.6 ± 2.1	1.0 ± 1.0	15.0 ± 4.1
Trichoptera - Total larvae	22.8 ± 8.6	12.8 ± 3.9	5.4 ± 4.3	16.2 ± 12.4	30.2 ± 16.3
Polycentropodidae	0.2 ± 0.4	0.2 ± 0.4		11.2 ± 11.6	1.2 ± 2.7
Rhyacophilidae	0.4 ± 0.5	0.4 ± 0.5			2.8 ± 2.2
Hydropsychidae	11.6 ± 4.8	8.4 ± 3.7	3.8 ± 2.9	2.2 ± 2.4	24.0 ± 14.1
Lepidostomatidae	8.6 ± 10.8	3.0 ± 1.6	1.0 ± 1.7	2.2 ± 1.6	1.2 ± 1.3
Brachycentridae	1.4 ± 1.3	0.2 ± 0.4		0.2 ± 0.4	
Hydroptilidae	0.2 ± 0.5		0.2 ± 0.4	0.4 ± 0.2	0.6 ± 1.3
Glossosomatidae	0.4 ± 0.5	0.4 ± 0.5			
Limnephilidae		0.2 ± 0.4	0.8 ± 0.8		
Leptoceridae					0.4 ± 0.8
Odonata					0.2 ± 0.4
Megaloptera: Sialidae		0.4 ± 0.5			
Coleoptera: Elmidae	0.6 ± 6.2	0.6 ± 0.9	1.0 ± 1.0		0.4 ± 0.5
Diptera					
Chironomidae	80.6 ± 53.5	118.0 ± 63.3	49.0 ± 13.6	323.6 ± 148.8	261.8 ± 156.0
Simuliidae	33.4 ± 39.4	11.8 ± 12.7	0.8 ± 0.8	1.6 ± 1.5	3.2 ± 0.8
Athericidae	2.8 ± 1.6	1.6 ± 1.3	2.8 ± 0.8	3.8 ± 1.6	10.8 ± 4.0
Other	3.2 ± 3.3	8.6 ± 5.0	5.0 ± 3.2	3.4 ± 2.4	22.8 ± 9.1
Hydracarina	14.2 ± 11.3	20.8 ± 18.6	15.6 ± 5.9	86.4 ± 68.3	45.0 ± 23.9
Nematoda		0.2 ± 0.4		0.2 ± 0.4	
Planaria	0.2 ± 0.4	0.2 ± 0.4	0.4 ± 0.5	0.4 ± 0.8	1.6 ± 3.6
Oligochaeta	0.4 ± 0.5	0.8 ± 1.1	0.2 ± 0.4	1.8 ± 2.5	2.4 ± 3.3
Totals	332.8 ± 137.2	243.6 ± 87.1	108.6 ± 17.0	433.4 ± 160.7	426.0 ± 181.1
Diversity Index	3.3 ± 0.20	2.8 ± 0.33	2.8 ± 0.27	1.5 ± 0.33	2.3 ± 0.33

* block treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 to 0750 h on 7 June 1980.

Table 5. Aquatic invertebrates collected from rock balls (mean ± S.D. n = 5), 4.2 km below double application block*, Young's Brook, York County, New Brunswick, 27 May to 19 August 1980

Date Days before or after first (second) application	27 May -7(-11)	5 June +2(-2)	10 June +7(+3)	8 July +35(+31)	19 Aug. +77(+73)
Ephemeroptera - Total nymphs	63.0 ± 7.8	100.5 ± 26.5	53.4 ± 18.7	26.8 ± 11.3	16.5 ± 11.6
Baetidae	1.6 ± 1.5	0.4 ± 0.5			
Ephemerellidae	17.8 ± 5.4	24.8 ± 5.0	20.2 ± 3.6	14.2 ± 4.8	10.0 ± 8.4
Heptageniidae	3.2 ± 2.2	5.6 ± 4.7	1.6 ± 1.8	0.4 ± 0.5	0.8 ± 1.0
Leptophlebiidae	40.4 ± 3.1	69.2 ± 21.7	31.6 ± 16.9	12.2 ± 9.5	5.2 ± 3.5
Plecoptera - Total nymphs	28.8 ± 7.4	42.6 ± 11.8	23.4 ± 16.1	40.8 ± 7.3	12.0 ± 6.3
Taeniopterygidae	0.4 ± 0.5	0.2 ± 0.4			
Leuctridae	3.6 ± 0.5	15.0 ± 6.0	11.4 ± 8.3	34.0 ± 5.1	7.0 ± 2.9
Nemouridae	0.2 ± 0.5	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	
Pteronarcyidae			0.4 ± 0.5	0.2 ± 0.4	
Perlidae	1.2 ± 1.3	4.8 ± 1.3	4.4 ± 1.1	4.8 ± 5.9	3.0 ± 2.8
Perlodidae	15.0 ± 5.0	9.8 ± 5.6	2.6 ± 3.3		1.0 ± 2.0
Chloroperlidae	8.2 ± 3.6	12.4 ± 7.3	4.4 ± 4.4	1.6 ± 1.5	1.0 ± 1.2
Trichoptera - Total larvae	30.0 ± 9.7	49.0 ± 11.2	56.6 ± 20.8	34.4 ± 11.6	43.0 ± 30.4
Polycentropodidae	0.4 ± 0.5	1.0 ± 1.0	0.6 ± 0.5	5.6 ± 3.2	4.2 ± 8.5
Rhyacophilidae	0.2 ± 0.4			0.4 ± 0.8	3.8 ± 2.9
Hydropsychidae	7.6 ± 1.8	20.8 ± 7.0	32.4 ± 5.5	1.8 ± 0.8	31.5 ± 20.8
Lepidostomatidae	17.2 ± 9.4	25.2 ± 5.6	21.0 ± 22.9	24.4 ± 9.1	1.5 ± 1.7
Brachycentridae	4.6 ± 2.1	1.2 ± 1.6			
Hydroptilidae		0.2 ± 0.4	0.2 ± 0.4		1.8 ± 3.5
Glossosomatidae		0.4 ± 0.5	0.2 ± 0.4		0.2 ± 0.5
Limnephilidae	0.2 ± 0.4	0.2 ± 0.4	0.2 ± 0.4	2.2 ± 1.8	
Megaloptera: Sialidae					0.2 ± 0.5
Coleoptera					
Elmidae				0.8 ± 1.3	1.5 ± 1.7
Haliplidae	0.2 ± 0.4			0.2 ± 0.4	
Diptera					
Chironomidae	57.6 ± 26.7	81.4 ± 28.1	56.0 ± 17.0	240.4 ± 117.9	90.0 ± 42.8
Simuliidae	11.0 ± 12.3	4.8 ± 4.5	5.6 ± 9.2	1.0 ± 1.0	0.2 ± 0.5
Athericidae	0.4 ± 0.5	0.2 ± 0.4			0.5 ± 0.6
Other	1.2 ± 0.8	10.0 ± 3.7	7.0 ± 3.9	17.0 ± 10.7	22.2 ± 8.5
Hydracarina	6.8 ± 3.3	11.0 ± 4.4	6.0 ± 3.7	9.6 ± 5.0	7.0 ± 1.8
Nematoda					
Planaria		0.4 ± 0.5		0.2 ± 0.4	0.8 ± 1.0
Oligochaeta	0.2 ± 0.4	1.2 ± 1.1	1.4 ± 1.9	10.6 ± 7.5	0.8 ± 1.5
Totals	199.4 ± 43.2	300.6 ± 60.6	207.4 ± 50.6	380.8 ± 134.1	194.5 ± 81.8
Diversity index	3.2 ± 0.18	3.3 ± 0.15	3.1 ± 0.22	2.2 ± 0.46	2.7 ± 0.07

* block treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 to 0750 h on 7 June 1980.

APPENDIX IV

Benthic organisms present in Surber samples collected from Young's Brook Watershed, May to September 1980.

Table 1. Bottom fauna from Surber samples (mean ± S.D. n = 4), upstream control station, Young's Brook, York County, New Brunswick, 25 May to 28 September 1980

Date	27 May	2 June	6 June	11 June	16 June	4 July	13 Aug.	28 Sept.
Ephemeroptera - Total nymphs	28.0 ± 9.2	12.8 ± 5.7	16.0 ± 1.6	24.2 ± 18.5	18.8 ± 14.3	9.2 ± 6.5	3.2 ± 1.9	11.5 ± 1.9
Baetidae	0.8 ± 1.5	1.5 ± 1.9	0.8 ± 1.5	6.5 ± 7.2	1.2 ± 0.5	0.5 ± 0.6	0.5 ± 0.6	
Ephemerellidae	9.8 ± 5.1	5.2 ± 2.6	9.8 ± 1.3	12.5 ± 10.5	10.0 ± 7.8	1.5 ± 1.3	1.2 ± 1.3	7.8 ± 2.2
Heptageniidae	17.2 ± 12.7	5.8 ± 2.6	3.5 ± 2.6	5.0 ± 8.0	5.2 ± 6.7	2.0 ± 0.8	1.5 ± 2.4	2.5 ± 1.7
Leptophlebiidae	0.2 ± 0.5	0.2 ± 0.5	2.0 ± 1.8	0.2 ± 0.5	2.0 ± 2.4	5.2 ± 6.6		1.2 ± 1.9
Odonata: Gomphidae								1.0 ± 0.8
Plecoptera	5.5 ± 7.1	5.5 ± 6.0	5.8 ± 4.1	3.2 ± 1.7	3.8 ± 3.9	10.5 ± 9.7	0.2 ± 0.5	23.0 ± 11.4
Megaloptera: Sialidae								0.2 ± 0.5
Trichoptera - Total larvae	7.0 ± 5.0	17.2 ± 18.5	9.8 ± 13.2	25.5 ± 19.4	4.0 ± 3.2	4.0 ± 2.7	1.2 ± 1.0	40.5 ± 34.5
Brachycentridae	4.2 ± 3.7	13.5 ± 16.9	9.0 ± 12.2	20.8 ± 18.6	2.2 ± 2.6	0.5 ± 1.8	0.2 ± 0.5	1.8 ± 2.1
Glossosomatidae		0.2 ± 0.5	0.2 ± 0.5	0.8 ± 0.5		0.2 ± 0.5		2.0 ± 3.4
Hydropsychidae	1.0 ± 1.4	0.5 ± 0.6	0.5 ± 0.6	2.6 ± 2.6	0.5 ± 1.0	0.5 ± 1.0	0.5 ± 0.6	6.8 ± 3.9
Hydroptilidae						0.5 ± 1.0		0.5 ± 1.0
Limnephilidae		0.8 ± 1.5		0.5 ± 0.6	0.2 ± 0.5	0.8 ± 1.5		0.8 ± 1.5
Polycentropodidae	0.5 ± 0.6			0.2 ± 0.5	0.5 ± 1.0			1.0 ± 0.8
Rhyacophilidae	1.2 ± 1.5	0.8 ± 1.0		0.5 ± 0.6	0.5 ± 1.0			1.0 ± 2.0
Lepidostomatidae								21.5 ± 29.6
pupae				0.5 ± 1.0		0.5 ± 0.6	0.5 ± 1.0	5.3 ± 10.5
Coleoptera								
Elmidae adults					0.2 ± 0.5		0.2 ± 0.5	0.2 ± 0.5
larvae			0.5 ± 1.0	0.8 ± 1.0			0.2 ± 0.5	1.0 ± 1.2
Diptera								
Tipulidae larvae	4.0 ± 6.1	3.2 ± 3.6	4.8 ± 3.9	3.5 ± 2.5	1.0 ± 1.4	2.2 ± 2.6	0.5 ± 1.0	7.0 ± 5.3
Simuliidae larvae	20.0 ± 15.4	24.8 ± 19.7	28.8 ± 16.1	101.7 ± 92.0	24.2 ± 24.0	4.8 ± 7.5	0.5 ± 0.6	0.2 ± 0.5
pupae	2.8 ± 2.2		0.5 ± 0.6	1.2 ± 0.5	5.8 ± 10.8	0.3 ± 1.5	1.5 ± 1.7	
Chironomidae larvae	62.2 ± 30.2	22.0 ± 20.3	33.2 ± 21.7	27.8 ± 29.0	10.2 ± 7.2	55.0 ± 54.0	15.8 ± 17.6	11.8 ± 1.9
pupae	3.0 ± 0.8	1.2 ± 1.3	0.5 ± 1.0	1.0 ± 0.8	2.2 ± 2.6	1.8 ± 1.5		0.2 ± 0.5
Heleidae larvae				0.8 ± 0.5		0.5 ± 0.6		0.2 ± 0.5
pupae								0.8 ± 1.0
Athericidae larvae	21.5 ± 14.0	3.8 ± 4.9	16.7 ± 13.7	15.8 ± 9.9	7.0 ± 10.1	7.2 ± 5.6	5.8 ± 4.6	16.8 ± 7.5
Empididae larvae		0.5 ± 0.6				0.2 ± 0.5		0.2 ± 0.5
pupae		0.2 ± 0.5		0.2 ± 0.5		0.2 ± 0.5		
Nematoda			0.5 ± 1.0					
Oligochaeta		0.8 ± 1.5	0.2 ± 0.5	0.5 ± 1.0		0.5 ± 0.6		0.5 ± 0.6
Pelecypoda	0.2 ± 0.5	0.2 ± 0.5		0.2 ± 0.5				0.5 ± 1.0
Arachnida: Hydracarina	0.2 ± 0.5		0.2 ± 0.5	1.5 ± 1.3	0.8 ± 1.0			0.6 ± 0.6
Crustacea: Turbellaria				0.2 ± 0.5				
Totals	159.5 ± 52.5	90.8 ± 89.9	89.0 ± 12.5	209.5 ± 117.3	77.8 ± 67.6	97.2 ± 74.4	29.5 ± 18.6	116.2 ± 44.3
Diversity index	2.60 ± 0.26	2.68 ± 0.27	2.71 ± 0.26	2.33 ± 0.48	2.66 ± 0.45	2.40 ± 0.55	2.01 ± 0.68	3.08 ± 0.27

Table 2. Bottom fauna from Surber samples (mean ± S.D. n = 4), McCallum Brook*, York County, New Brunswick, 25 May to 28 September 1980

Date	25 May	2 June	6 June	10 June	18 June	4 July	13 Aug.	28 Sept.
Days before or after Permethrin application	-9	-1	+3	+7	+15	+31	+71	+117
Ephemeroptera - Total nymphs	8.0 ± 5.6	10.8 ± 9.7	18.2 ± 11.9	17.0 ± 4.2	10.5 ± 6.8	6.0 ± 2.6	5.0 ± 8.0	14.0 ± 4.2
Baetidae		1.2 ± 1.3	1.2 ± 1.3	0.8 ± 0.5			3.5 ± 5.1	1.0 ± 1.2
Ephemerellidae	3.8 ± 4.5	7.0 ± 7.2	15.0 ± 10.7	14.8 ± 4.2	9.0 ± 6.7	5.2 ± 2.6	1.5 ± 3.0	10.8 ± 4.0
Heptageniidae	3.8 ± 1.5	3.8 ± 1.5	1.8 ± 3.5	2.0 ± 0.8	1.5 ± 3.0			0.3 ± 0.5
Leptophlebiidae	0.5 ± 1.0	0.8 ± 1.0			1.5 ± 1.0	0.8 ± 1.0		2.0 ± 1.6
Plecoptera	0.2 ± 0.5	0.2 ± 0.5	0.8 ± 1.5	0.8 ± 1.0	0.8 ± 0.5	0.2 ± 0.6	0.5 ± 1.0	12.2 ± 4.9
Trichoptera - Total larvae	2.8 ± 2.5	3.5 ± 5.1	0.8 ± 1.5	1.8 ± 1.7	0.5 ± 0.6	0.8 ± 1.0	3.5 ± 5.6	41.0 ± 18.8
Brachycentridae		1.0 ± 1.4		0.5 ± 0.6				3.5 ± 8.1
Glossosomatidae	0.5 ± 0.6	1.8 ± 2.9		0.2 ± 0.5			1.2 ± 1.9	0.8 ± 1.0
Hydropsychidae	0.5 ± 1.0	0.2 ± 0.5				0.2 ± 0.5	1.5 ± 2.4	5.0 ± 3.6
Leptoceridae					0.2 ± 0.5			
Lepidostomatidae								25.8 ± 13.1
Limnephilidae	0.2 ± 0.5			0.8 ± 1.0	0.2 ± 0.5	0.2 ± 0.5	0.2 ± 0.5	
Odontoceridae		0.5 ± 1.0	0.2 ± 0.5					
Philopotamidae	0.2 ± 0.5						0.8 ± 1.5	
Polycentropodidae				0.2 ± 0.5		0.2 ± 0.5		0.8 ± 0.5
Rhyacophilidae	1.2 ± 2.5		0.5 ± 0.6					2.2 ± 2.1
pupae		3.0 ± 6.0			0.2 ± 0.5			
Coleoptera								
Elmidae adults			0.5 ± 0.6	0.2 ± 0.5	0.2 ± 0.5			0.2 ± 0.5
larvae				0.2 ± 0.5		0.6 ± 0.6		0.5 ± 1.0
Diptera								
Tipulidae larvae	3.5 ± 3.1	9.5 ± 11.2	3.8 ± 0.5	8.5 ± 3.3	2.8 ± 2.6	4.2 ± 2.9	0.5 ± 0.6	4.8 ± 7.5
Simuliidae larvae	2.2 ± 1.7	1.5 ± 1.0	4.2 ± 4.5	0.8 ± 1.5	0.5 ± 1.0	1.5 ± 1.9	3.5 ± 3.2	
pupae			0.2 ± 0.5		0.2 ± 0.5			
Chironomidae larvae	8.5 ± 7.0	28.8 ± 29.2	21.5 ± 8.4	25.[illegible] ± 32.3	19.0 ± 12.0	112.2 ± 32.7	14.2 ± 15.6	4.0 ± 4.3
pupae	1.5 ± 2.4	1.2 ± 1.3	1.8 ± 1.5	1.2 ± 1.9	10.0 ± 5.4	13.5 ± 2.4	0.5 ± 0.6	0.2 ± 0.5
Heleidae larvae				0.2 ± 0.5		0.2 ± 0.5	2.8 ± 1.7	2.0 ± 2.3
pupae								0.8 ± 1.0
Athericidae larvae	7.2 ± 7.9	24.2 ± 23.6	9.0 ± 4.6	17.2 ± 12.6	5.8 ± 6.0	30.5 ± 12.7	24.2 ± 23.0	37.2 ± 13.3
Empididae larvae	0.5 ± 1.0	0.2 ± 0.5		0.5 ± 0.6		0.5 ± 1.0		
pupae		0.2 ± 0.5		0.2 ± 0.5		0.8 ± 1.0		
Psychodidae larvae								0.2 ± 0.5
Nematoda	0.2 ± 0.5		0.2 ± 0.5	0.2 ± 0.5		0.5 ± 0.6		0.2 ± 0.5
Oligochaeta	18.8 ± 25.7	25.8 ± 15.1	19.8 ± 13.2	24.0 ± 15.9	3.5 ± 4.4	64.5 ± 68.6	10.2 ± 13.4	20.8 ± 10.9
Pelecypoda	0.2 ± 0.5			0.2 ± 0.5				0.2 ± 0.5
Arachnida: Hydrocarina				0.8 ± 1.5				
Totals	53.8 ± 43.7	66.0 ± 76.1	80.8 ± 14.4	99.8 ± 44.5	55.0 ± 31.4	236.3 ± 53.3	65.25 ± 46.8	140.25 ± 57.4
Diversity index	2.73 ± 0.37	2.13 ± 0.91	2.57 ± 0.26	2.53 ± 0.24	2.52 ± 0.39	1.88 ± 0.09	2.38 ± 0.51	3.02 ± 0.29

* treated with 17.5 g AI/ha permethrin at 1850 h on 3 June 1980.

Table 3. Bottom fauna from Surber samples (mean ± S.D., n = 4), double application, Young's Brook, York County, New Brunswick, 25 May to 28 September 1980

Date Days before or after first (second application)	24 May -10 (+4)	2 June -1 (-5)	6 June +3 (-1)	12 June +9 (+5)	17 June +14 (+10)	4 July +31 (+27)	13 Aug. +71 (+67)	28 Sept. +117 (113)
Ephemeroptera - Total nymphs	14.0 ± 13.3	11.2 ± 4.4	9.5 ± 4.2	2.2 ± 1.7	1.5 ± 1.3	1.5 ± 2.4	1.5 ± 1.7	3.0 ± 1.2
Baetidae	4.3 ± 4.4	2.2 ± 1.7	0.2 ± 0.5			0.5 ± 1.0	1.5 ± 1.7	1.0 ± 1.4
Ephemerellidae	4.0 ± 3.8	3.8 ± 1.3	5.2 ± 4.7	2.0 ± 1.8	1.2 ± 1.0	0.2 ± 0.5		1.5 ± 0.6
Heptageniidae	2.0 ± 2.7	4.5 ± 1.7	1.5 ± 1.3	0.2 ± 0.5				0.2 ± 0.5
Leptophlebiidae	3.8 ± 5.2	0.8 ± 1.0	2.2 ± 2.6		0.2 ± 0.5	0.8 ± 0.5		0.2 ± 0.5
Baetiscidae			0.2 ± 0.5				0.2 ± 0.5	
Odonata: Gomphidae		0.2 ± 0.5	0.2 ± 0.5		0.2 ± 0.5			2.6 ± 3.2
Plecoptera	3.2 ± 1.0	7.5 ± 3.3	2.8 ± 1.5	1.2 ± 1.0	1.8 ± 1.7	2.8 ± 2.1	1.8 ± 2.9	5.5 ± 3.1
Megaloptera: Sialidae	0.2 ± 0.5	0.2 ± 0.5	0.5 ± 1.0					0.2 ± 0.5
Trichoptera - Total larvae	2.5 ± 2.4	16.5 ± 5.7	5.5 ± 2.9	3.3 ± 3.3	3.0 ± 4.1	1.2 ± 0.5	14.5 ± 9.7	18.8 ± 15.1
Brachycentridae	1.2 ± 1.9		2.0 ± 1.4		0.8 ± 1.5	0.2 ± 0.5		
Glossosomatidae	1.2 ± 1.9	11.0 ± 4.7	2.5 ± 0.6	0.8 ± 1.0	1.0 ± 0.8	0.2 ± 0.5	13.8 ± 9.1	6.2 ± 4.9
Hydropsychidae		0.8 ± 1.5	0.8 ± 1.0		0.8 ± 0.5	0.5 ± 1.0	1.2 ± 1.5	5.2 ± 3.6
Hydroptilidae			0.2 ± 0.5					
Lepidostomatidae		3.8 ± 5.7		2.5 ± 2.9	0.5 ± 1.0	0.2 ± 0.5		1.8 ± 1.5
Leptoceridae		0.5 ± 1.0					0.2 ± 0.5	
Limnephilidae	0.2 ± 0.5	0.2 ± 0.5	0.5 ± 1.0		0.2 ± 0.5			
Odontoceridae					0.2 ± 0.5			
Polycentropodidae		0.2 ± 0.5						1.8 ± 1.3
Rhyacophilidae			0.2 ± 0.5					1.2 ± 1.5
Philopotamidae							0.5 ± 1.0	
pupae	0.2 ± 0.5	10.0 ± 7.2	2.5 ± 1.9	1.5 ± 1.9	3.0 ± 1.4	1.7 ± 1.5		2.5 ± 2.9
Coleoptera								
Elmidae adults			0.2 ± 0.5	0.5 ± 1.0			0.2 ± 0.5	0.5 ± 0.6
larvae	0.2 ± 0.5			0.2 ± 0.5	0.2 ± 0.5	0.8 ± 0.5	0.2 ± 0.5	0.8 ± 1.0
Psephenidae larvae			0.2 ± 0.5					
Diptera								
Tipulidae larvae	5.0 ± 5.7	6.2 ± 7.1	4.2 ± 4.6	1.2 ± 1.3	1.2 ± 1.3	3.3 ± 3.0	2.0 ± 2.4	3.8 ± 1.7
Simuliidae larvae	4.2 ± 4.8	1.8 ± 2.9	9.0 ± 8.5				0.8 ± 1.5	0.2 ± 0.5
pupae	0.8 ± 1.0			0.8 ± 1.5				0.2 ± 0.5
Chironomidae larvae	10.2 ± 7.9	7.2 ± 8.2	25.8 ± 35.3	21.5 ± 18.2	19.0 ± 14.7	38.0 ± 11.8	8.2 ± 2.5	2.0 ± 1.4
pupae	2.2 ± 1.9	0.2 ± 0.5	1.0 ± 1.4	0.2 ± 0.5	0.2 ± 0.5	5.0 ± 6.2	0.8 ± 1.0	0.2 ± 0.5
Heleidae larvae			0.2 ± 0.5		2.0 ± 3.4		1.5 ± 1.2	0.8 ± 1.5
pupae						0.2 ± 0.5		
Athericidae larvae		0.2 ± 0.5	0.8 ± 1.0	1.2 ± 1.9	0.5 ± 0.6	0.8 ± 0.5		2.5 ± 3.8
Empididae larvae		0.8 ± 1.0		0.2 ± 0.5		0.8 ± 1.0		
pupae			0.8 ± 0.5	0.2 ± 0.5		0.5 ± 0.6		
Aquatic Lepidoptera larvae					0.2 ± 0.5			
Nematoda			0.2 ± 0.5			0.2 ± 0.5		0.2 ± 0.5
Oligochaeta	1.8 ± 1.5	5.0 ± 4.6	9.2 ± 14.0	1.5 ± 1.7	10.0 ± 13.6	12.5 ± 5.6	14.5 ± 17.2	17.8 ± 11.5
Gastropoda						1.5 ± 1.7		
Pelecypoda				0.2 ± 0.5	0.2 ± 0.5	1.2 ± 2.5		4.2 ± 8.8
Arachnida: Hydracarina				1.0 ± 0.8	2.2 ± 3.2			
Crustacea: Decapoda		0.2 ± 0.5						0.2 ± 0.5
Totals	43.8 ± 21.2	70.0 ± 24.8	73.6 ± 29.2	38.0 ± 20.7	46.0 ± 27.2	71.8 ± 13.4	63.8 ± 18.7	63.85 ± 20.2
Diversity index	2.99 ± 0.34	3.14 ± 0.26	2.89 ± 0.77	2.18 ± 0.45	2.47 ± 0.44	2.19 ± 0.61	2.16 ± 0.40	3.18 ± 0.35

* Treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June, and again 0600 to 0750 h on 7 June, 1980.

Table 4. Bottom fauna from Surber samples (mean ± S.D. n = 4), 1.4 km downstream of treatment block[a], Young's Brook, York County, New Brunswick, 26 May to 28 September 1980

Date Days before or after first (second application)	26 May -8 (-13)	2 June -1 (-5)	6 June +3 (-1)	12 June +9 (+5)	18 June +15 (+11)	4 July +31 (+27)	13 Aug. +71 (+67)	28 Sept. +117 (113)
Ephemeroptera - Total nymphs	60.8 ± 42.4	36.8 ± 34.5	12.0 ± 5.2	9.2 ± 6.8	7.2 ± 4.2	9.5 ± 4.1	4.2 ± 4.0	6.2 ± 6.7
Baetidae	19.2 ± 15.1	15.0 ± 18.1	0.2 ± 0.5	0.2 ± 0.5	0.2 ± 0.5		2.5 ± 3.1	5.0 ± 5.7
Baetiscidae		0.2 ± 0.5					0.5 ± 0.6	0.2 ± 0.5
Ephemerellidae	31.7 ± 35.9	6.0 ± 5.5	6.5 ± 3.3	3.8 ± 2.2	3.5 ± 2.6	5.0 ± 3.5		0.5 ± 1.0
Heptageniidae	7.8 ± 4.6	13.0 ± 11.6	0.5 ± 0.6	1.0 ± 2.0			0.8 ± 1.0	0.2 ± 0.5
Leptophlebiidae	5.8 ± 1.3	2.5 ± 3.8	4.0 ± 5.7	4.2 ± 4.6	3.5 ± 3.1	4.5 ± 1.9	0.5 ± 1.0	0.2 ± 0.5
Odonata: Gomphidae							0.2 ± 0.5	0.2 ± 0.5
Plecoptera	8.8 ± 8.6	7.5 ± 4.5	5.8 ± 7.0	2.0 ± 2.2			2.8 ± 2.9	6.5 ± 2.5
Trichoptera - Total larvae	27.8 ± 17.8	20.2 ± 2.4	22.0 ± 12.8	29.2 ± 32.9	8.2 ± 6.2	20.0 ± 11.6	33.2 ± 30.5	101.8 ± 50.5
Brachycentridae	5.2 ± 5.1	5.5 ± 1.3	1.8 ± 1.5	0.7 ± 1.5	0.2 ± 0.5			
Glossosomatidae	3.8 ± 4.4	7.5 ± 3.1	2.2 ± 1.0	4.5 ± 5.1	0.2 ± 0.5	0.8 ± 1.0	13.8 ± 6.0	10.8 ± 4.6
Hydropsychidae	12.2 ± 8.9	4.0 ± 3.7	4.8 ± 3.3	7.9 ± 9.2	4.0 ± 2.9	4.8 ± 1.5	16.5 ± 25.2	53.5 ± 31.9
Lepidostomatidae	4.2 ± 5.1	2.5 ± 5.0	11.8 ± 15.6	12.5 ± 14.9	3.8 ± 3.9	11.5 ± 9.8	0.5 ± 0.6	26.5 ± 20.1
Limnephilidae	0.2 ± 0.5							
Odontoceridae				0.2 ± 0.5				
Philopotamidae						0.8 ± 1.0	1.0 ± 2.0	1.0 ± 1.4
Polycentropodidae		0.5 ± 1.0	0.2 ± 0.5					1.8 ± 2.4
Rhyacophilidae	1.2 ± 1.0						0.2 ± 0.5	4.8 ± 3.4
pupae	0.2 ± 0.5		1.2 ± 1.9			2.2 ± 2.6	1.2 ± 1.3	3.5 ± 5.1
Coleoptera								
Elmidae adults	1.0 ± 2.0	0.2 ± 0.5	0.2 ± 0.5		0.8 ± 1.0		0.2 ± 0.5	1.0 ± 1.4
larvae	0.5 ± 0.6	0.5 ± 1.0	1.2 ± 1.9	0.8 ± 1.0		1.2 ± 1.3	1.2 ± 1.3	3.2 ± 2.5
Psephenidae larvae		0.5 ± 1.0		0.2 ± 0.5				
Diptera								
Tipulidae larvae	8.8 ± 7.6	12.7 ± 10.7	12.8 ± 13.6	8.8 ± 4.7	4.0 ± 2.6	5.5 ± 1.0	2.5 ± 1.9	19.8 ± 11.4
Simuliidae larvae	8.5 ± 11.4	2.5 ± 2.7	17.5 ± 12.6	0.5 ± 1.0	0.5 ± 1.0		0.2 ± 0.5	
pupae			1.5 ± 1.3	0.5 ± 1.0	0.8 ± 1.0			
Chironomidae larvae	55.5 ± 40.2	27.2 ± 34.8	20.8 ± 16.7	10.8 ± 7.1	29.2 ± 15.4	173.0 ± 56.1	26.0 ± 21.6	39.0 ± 29.7
pupae	4.7 ± 2.1	1.0 ± 1.4	2.5 ± 3.0	0.2 ± 0.5	1.2 ± 1.5	6.0 ± 2.4	0.2 ± 0.5	1.2 ± 0.5
Heleidae larvae	1.0 ± 0.8				0.5 ± 0.6	3.0 ± 3.8		3.0 ± 1.8
pupae						0.5 ± 1.0		
Athericidae larvae	0.5 ± 1.0	0.8 ± 1.0					0.2 ± 0.5	0.5 ± 0.6
Empididae larvae			0.2 ± 0.5					0.5 ± 0.6
pupae	0.2 ± 0.5		0.2 ± 0.5		0.2 ± 0.5			
Oligochaeta	5.3 ± 3.9	0.5 ± 1.0	0.5 ± 0.1	2.0 ± 4.0		1.8 ± 1.3	8.3 ± 10.2	18.5 ± 11.7
Gastropoda	0.2 ± 0.5	0.2 ± 0.5						0.2 ± 0.5
Pelecypoda							0.2 ± 0.5	0.2 ± 0.5
Arachnida: Hydracarina			0.5 ± 0.6	0.2 ± 0.5			0.5 ± 0.6	
Crustacea: Turbellaria						0.2 ± 0.5	0.2 ± 0.5	3.8 ± 3.8
Totals	183.5 ± 123.7	107.2 ± 26.1	97.8 ± 27.5	64.5 ± 36.7	52.8 ± 27.5	221.2 ± 55.0	82.8 ± 36.0	205.8 ± 100.5
Diversity index	3.24 ± 0.20	2.80 ± 0.70	2.86 ± 0.32	2.73 ± 0.55	2.06 ± 0.50	1.43 ± 0.44	2.70 ± 0.22	3.11 ± 0.13

[a] located 1.4 km downstream from double application block on Young's Brook treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 to 0750 h on 6 June 1980.

Table 5. Bottom fauna from Surber samples (mean ± S.D. n = 4), 4.2 km downstream of treatment block[a], Young's Brook, York County, New Brunswick, 26 May to 28 September 1980

Date Days before or after first (second application)	26 May -8 (-12)	2 June -1 (-5)	6 June +3 (-1)	12 June +9 (+5)	17 June +14 (+10)	4 July +31 (+27)	13 Aug. +71 (+67)	28 Sept. +117 (+113)
Ephemeroptera - Total nymphs	13.8 ± 11.1	23.5 ± 22.1	16.5 ± 11.4	4.5 ± 6.4	4.2 ± 1.3	4.0 ± 4.9	4.5 ± 3.7	8.5 ± 1.0
Baetidae	1.0 ± 1.4	2.5 ± 3.1	3.0 ± 5.4	0.2 ± 0.5	0.5 ± 1.0		3.5 ± 3.1	2.5 ± 2.4
Ephemerellidae	5.5 ± 5.0	9.5 ± 9.0	9.8 ± 6.6	2.5 ± 2.6	1.2 ± 1.5	0.5 ± 1.0	0.5 ± 1.0	1.2 ± 1.0
Heptageniidae	3.0 ± 2.4	7.0 ± 7.8	2.5 ± 2.4	1.5 ± 3.0	1.0 ± 0.8	0.8 ± 1.0	0.5 ± 1.0	1.8 ± 1.0
Leptophlebiidae	4.2 ± 2.9	4.5 ± 3.7	1.2 ± 1.3	0.2 ± 0.5	1.5 ± 1.3	2.8 ± 3.2		2.5 ± 2.6
Baetiscidae					0.2 ± 0.5			0.2 ± 0.5
Odonata: Gomphidae			0.2 ± 0.5			1.8 ± 2.1	0.5 ± 0.6	1.2 ± 1.9
Plecoptera	7.2 ± 5.5	12.0 ± 4.6	8.0 ± 6.8	1.8 ± 1.7	1.8 ± 3.5	1.0 ± 2.0	0.8 ± 1.0	14.0 ± 4.1
Megaloptera: Sialidae					0.2 ± 0.5			0.2 ± 0.5
Trichoptera - Total larvae	30.2 ± 17.8	30.0 ± 8.1	18.8 ± 14.4	10.2 ± 8.9	13.8 ± 8.0	6.2 ± 5.1	8.2 ± 2.2	36.0 ± 12.7
Brachycentridae	19.8 ± 12.2	12.8 ± 8.6	8.0 ± 5.0	3.2 ± 3.4	8.5 ± 6.2	3.0 ± 3.4	0.2 ± 0.5	0.2 ± 0.5
Glossosomatidae	2.2 ± 2.2	8.8 ± 9.2	1.2 ± 1.5	2.5 ± 1.0	2.8 ± 5.5	1.0 ± 1.4	4.5 ± 1.7	2.8 ± 2.2
Hydropsychidae	5.5 ± 4.6	3.8 ± 4.4	6.8 ± 7.1	5.2 ± 3.8	1.8 ± 2.9	0.2 ± 0.5	2.2 ± 2.2	12.0 ± 9.5
Hydroptilidae		1.8 ± 2.2	0.2 ± 0.5			0.2 ± 0.5		0.2 ± 0.5
Lepidostomatidae		2.5 ± 3.8			0.5 ± 0.6	0.2 ± 0.5	0.5 ± 0.6	18.8 ± 5.0
Polycentropodidae								1.0 ± 2.0
Limnephilidae		0.2 ± 0.5				0.2 ± 0.5		0.8 ± 1.5
Philopotamidae						0.2 ± 0.5	0.8 ± 1.0	
Rhyacophilidae	2.8 ± 5.5	0.2 ± 0.5			0.2 ± 0.5	0.2 ± 0.5		
pupae	0.2 ± 0.5	0.2 ± 0.5	0.5 ± 0.6	2.0 ± 1.8	0.5 ± 1.0	4.7 ± 6.4		0.2 ± 5.0
Coleoptera								
Elmidae adults								0.5 ± 0.6
larvae		0.8 ± 0.5	1.0 ± 0.8			1.2 ± 1.3	0.8 ± 1.0	1.2 ± 2.5
Psephenidae larvae			0.5 ± 1.0		1.2 ± 2.5	6.2 ± 12.3		
Diptera								
Tipulidae larvae	9.5 ± 8.4	12.8 ± 9.5	3.0 ± 1.8	5.2 ± 5.2	1.2 ± 1.9	3.5 ± 5.7	1.2 ± 1.0	15.0 ± 13.2
Simuliidae larvae	1.2 ± 1.3	0.5 ± 1.0	12.8 ± 6.7	1.8 ± 1.3				
pupae			0.2 ± 0.5	0.5 ± 1.0	18.5 ± 22.1	33.0 ± 66.0		
Chironomidae larvae	73.2 ± 63.2	40.8 ± 46.2	36.2 ± 7.9	20.2 ± 6.7	15.0 ± 17.3	46.8 ± 74.3	81.8 ± 67.1	32.0 ± 18.1
pupae	3.0 ± 2.2	1.2 ± 1.3	1.5 ± 1.7		1.5 ± 1.3	2.0 ± 4.0	3.3 ± 0.6	
Heleidae larvae	0.8 ± 1.0	0.2 ± 0.5		0.8 ± 1.0	3.2 ± 2.8	1.0 ± 1.4	0.5 ± 1.0	0.8 ± 1.0
Athericidae larvae	0.5 ± 1.0	0.5 ± 1.0	0.8 ± 1.5		0.8 ± 1.0	1.0 ± 1.4		2.0 ± 1.6
Empididae larvae	1.8 ± 1.7	0.5 ± 0.6	0.2 ± 0.5	0.2 ± 0.5		0.2 ± 0.5		1.2 ± 1.9
pupae		0.2 ± 0.5	0.5 ± 1.0	0.2 ± 0.5	0.8 ± 1.0	0.5 ± 0.6		
Oligochaeta	3.0 ± 1.4	1.5 ± 1.7	3.8 ± 2.1	1.0 ± 1.4	1.2 ± 1.9	5.2 ± 3.5	2.5 ± 1.9	10.0 ± 4.1
Gastropoda		0.5 ± 1.0						0.5 ± 0.6
Pelecypoda	2.2 ± 1.7	0.5 ± 1.0	1.0 ± 2.0	0.5 ± 0.5		1.2 ± 1.0		0.8 ± 1.5
Arachnida: Hydracarina				0.8 ± 1.0				
Crustacea: Turbellaria								0.2 ± 0.5
Totals	146.8 ± 103.3	150.8 ± 36.8	103.0 ± 40.7	48.2 ± 19.8	65.0 ± 16.3	116.2 ± 111.5	103.0 ± 72.8	124.2 ± 40.3
Diversity index	2.60 ± 0.46	2.87 ± 0.55	2.93 ± 0.41	2.42 ± 0.83	2.27 ± 0.61	2.16 ± 0.25	1.49 ± 0.41	3.13 ± 0.23

[a] located 4.2 km downstream from double application block on Young's Brook treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 to 0750 h on 6 June 1980.

APPENDIX V

Native fish collected from Young's Brook watershed for stomach content analysis, May to September 1980.

Table 1. 1+ Atlantic salmon collected from single application block*, McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	27 May	6 June	1 July	15 Aug.	26 Sept.
No. of fish sampled	10	9	10	9	10
Mean total length (mm)	60.5 ± 4.3	64.2 ± 4.5	69.5 ± 8.3	83.1 ± 4.0	89.4 ± 5.6
Range	55-69	57-70	63-74	75-88	83-98
Mean fork length (mm)	57.2 ± 4.5	61.1 ± 4.2	66.4 ± 3.7	76.3 ± 3.4	82.1 ± 5.3
Range	52-64	55-67	61-71	69-80	76-83
Mean weight (g)	2.66 ± 0.37	2.96 ± 1.72	4.26 ± 0.69	6.39 ± 0.91	6.63 ± 1.13
Range	2.2 - 3.3	2.0 - 3.8	3.2 - 5.1	4.3 - 7.4	4.9 - 8.3
Mean volume Stomach contents (ml)	0.07 ± 0.05	0.10 ± 0.09	0.08 ± 0.07	0.06 ± 0.03	0.07 ± 0.03
Range	0.0 - 0.2	0.0 - 0.3	<0.1 - 0.3	0.0 - 0.1	<0.1 - 0.1
Condition Coefficient	1.20	1.10	1.26	1.11	0.92

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 2. 1+ Atlantic salmon collected from double application block*, Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	26 May	8 June	2 July	15 Aug.	26 Sept.
No. of fish sampled	11	10	10	10	10
Mean total length (mm)	69.1 ± 4.2	72.7 ± 5.8	76.6 ± 5.2	88.6 ± 4.5	94.2 ± 6.0
Range	63-77	66-85	67-85	81-96	90-105
Mean fork length (mm)	64.3 ± 3.6	69.4 ± 5.3	73.5 ± 5.0	81.0 ± 3.9	86.2 ± 5.3
Range	59-71	63-80	64-81	75-87	82-96
Mean weight (g)	3.27 ± 0.59	4.86 ± 0.85	5.43 ± 1.12	8.19 ± 0.99	7.93 ± 1.46
Range	2.6 - 4.7	4.0 - 7.0	3.3 - 7.0	6.4 - 9.6	6.3 - 10.5
Mean volume Stomach contents (ml)	0.07 ± 0.08	0.15 ± 0.12	0.10 ± 0.08	0.10 ± 0.08	0.12 ± 0.11
Range	<0.1 - 0.3	<0.1 - 0.4	<0.1 - 0.3	0 - 0.2	<0.1 - 0.3
Condition coefficient	0.99	1.27	1.20	1.16	0.94

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 3. 1+ Atlantic salmon collected from untreated control area, Young's Brook, York County, New Brunswick, 2 July to 27 September 1980

	2 July	15 Aug.	27 Sept.
No. of fish sampled	4	8	9
Mean total length (mm)	81.0 ± 8.8	93.6 ± 6.5	98.4 ± 4.8
Range	79-85	85-103	93-109
Mean fork length (mm)	77.2 ± 1.9	87.2 ± 6.2	90.7 ± 4.2
Range	76-80	79-95	86-99
Mean weight (g)	5.70 ± 0.41	9.54 ± 2.52	8.88 ± 1.43
Range	5.2 - 6.2	7.0 - 14.2	6.6 - 11.7
Mean volume Stomach contents (mL)	0.11 ± 0.06	0.04 ± 0.03	0.06 ± 0.02
Range	<0.1 - 0.2	0.0 - 0.1	<0.1 - 0.1
Condition coefficient	1.08	1.14	0.93

Table 4. 2+ Atlantic salmon collected from single application block*, McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	27 May	6 June	1 July	15 Aug.	26 Sept.
No. of fish sampled	10	10	10	9	10
Mean total length (mm)	89.0 ± 4.2	100.5 ± 4.3	101.4 ± 7.8	116.8 ± 6.5	123.1 ± 5.9
Range	81-95	92-107	89-112	108-126	114-132
Mean fork length (mm)	83.1 ± 3.8	95.0 ± 4.2	97.3 ± 8.1	108.6 ± 5.5	114.1 ± 5.9
Range	75-88	86-100	85-109	101-120	105-123
Mean weight (g)	8.21 ± 1.17	10.58 ± 1.46	12.19 ± 2.74	15.72 ± 2.05	16.51 ± 2.2
Range	6.4 - 10.0	8.2 - 12.6	9.1 - 18.0	13.3 - 19.9	13.9 - 20.5
Mean volume Stomach contents (ml)	0.19 ± 0.14	0.62 ± 0.20	0.10 ± 0.07	0.08 ± 0.09	0.08 ± 0.06
Range	0.0 - 0.4	0.3 - 1.0	<0.1 - 0.3	0.0 - 0.3	0.0 - 0.2
Condition coefficient	1.16	1.04	1.16	0.99	0.88

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 5. 2+ Atlantic salmon collected from double application block*, Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	26 May	8 June	2 July	15 Aug.	26 Sept.
No. of fish sampled	11	10	10	10	10
Mean total length (mm)	105.9 ± 10.1	110.1 ± 9.3	111.2 ± 6.6	122.8 ± 11.3	135.2 ± 11.0
Range	97-130	101-131	103-120	99-137	118-151
Mean fork length (mm)	96.2 ± 12.3	103.2 ± 9.8	106.5 ± 6.8	112.5 ± 10.0	123.7 ± 9.5
Range	70-120	95-125	98-116	91-125	109-139
Mean weight (g)	12.12 ± 3.52	15.02 ± 3.34	15.10 ± 3.10	19.62 ± 4.80	19.84 ± 4.07
Range	10.5 - 20.7	11.0 - 23.0	11.0 - 20.2	11.0 - 27.9	15.2 - 29.1
Mean volume Stomach contents (ml)	0.42 ± 0.21	0.76 ± 0.35	0.32 ± 0.40	0.10 ± 0.10	0.34 ± 0.64
Range	0.1 - 0.8	0.4 - 1.3	<0.1 - 1.3	0 - 0.3	0 - 2.1
Condition coefficient	1.00	1.12	1.09	1.04	0.80

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 6. 2+ Atlantic salmon collected from untreated control area, Young's Brook, York County, New Brunswick, 27 May to 27 September 1980

	27 May	7 June	2 July	15 Aug.	27 Sept.
No. of fish sampled	9	10	10	10	10
Mean total length (mm)	103.2 ± 8.6	103.8 ± 10.1	119.9 ± 8.2	119.8 ± 8.1	132.1 ± 12.9
Range	95-125	95-125	110-134	109-131	115-152
Mean fork length (mm)	95.4 ± 7.7	98.3 ± 9.1	114.4 ± 7.7	112.0 ± 7.6	122.1 ± 12.4
Range	88-115	90-118	105-127	100-121	106-141
Mean weight (g)	10.74 ± 2.47	12.29 ± 3.55	19.11 ± 2.99	17.18 ± 2.10	19.15 ± 4.40
Range	8.4 - 16.4	9.1 - 20.0	15.7 - 24.7	13.1 - 20.0	13.2 - 26.2
Mean volume Stomach contents (ml)	0.28 ± 0.19	0.40 ± 0.14	0.32 ± 0.11	0.22 ± 0.39	0.24 ± 0.15
Range	<0.1 - 0.7	0.2 - 0.7	0.15 - 0.5	0.0 - 1.1	<0.1 - 0.5
Condition coefficient	0.96	1.07	1.11	0.98	0.82

Table 7. Brook trout collected from single application block*, McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	27 May	6 June	1 July	15 Aug.	26 Sept.
No. of fish sampled	10	10	10	5	10
Mean total length (mm)	112.5 ± 21.5	136.8 ± 26.4	109.6 ± 20.2	129.0 ± 37.9	83.7 ± 19.6
Range	79-155	110-186	74-144	84-174	65-112
Mean fork length (mm)	107.4 ± 21.4	130.4 ± 25.3	107.6 ± 19.7	123.4 ± 37.5	83.2 ± 19.1
Range	74-150	106-178	77-141	79-169	61-107
Mean weight (g)	17.17 ± 9.07	34.8 ± 22.49	17.43 ± 10.42	30.26 ± 21.85	7.00 ± 4.20
Range	5.9 - 38.5	15.0 - 80.8	6.5 - 38.7	7.2 - 59.4	2.4 - 12.7
Mean volume Stomach contents (ml)	0.58 ± 0.58	4.58 ± 2.85	0.22 ± 0.13	0.43 ± 0.46	0.10 ± 0.08
Range	0.1 - 2.0	1.2 - 10.0	0.1 - 0.5	<0.1 - 1.2	0.0 - 0.25
Condition coefficient	1.12	1.22	1.21	1.18	0.94

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 8. Brook trout collected from double application block*, Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	26 May	8 June	2 July	26 Sept.
No. of fish sampled	8	11	2	10
Mean total length (mm)	121.9 ± 6.6	115.5 ± 26.9	148.5 ± 14.8	118.4 ± 21.9
Range	113-131	64-145	138-159	86-168
Mean fork length (mm)	116.1 ± 6.0	111.2 ± 25.9	145.0 ± 14.1	113.2 ± 21.2
Range	108-125	62-140	135-155	81-160
Mean weight (g)	19.28 ± 2.82	24.43 ± 15.53	41.05 ± 19.73	16.97 ± 11.0
Range	16.0 - 24.0	3.0 - 48.6	27.1 - 55.0	5.9 - 21.5
Mean volume Stomach contents (ml)	1.41 ± 0.66	2.58 ± 2.06	0.28 ± 0.18	0.15 ± 0.16
Range	0.4 - 2.5	0.1 - 6.9	0.15 - 0.4	0 - 0.5
Condition coeffficient	1.06	1.32	1.20	0.93

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 9. Brook trout collected from untreated control area, Young's Brook, York County, New Brunswick, 27 May to 27 September 1980

	27 May	7 June	2 July	15 Aug.	27 Sept.
No. of fish sampled	10	12	10	10	10
Mean total length (mm)	109.6 ± 34.6	100.6 ± 18.8	107.1 ± 25.2	131.5 ± 17.8	139.3 ± 10.3
Range	72-175	70-126	77-146	103-158	123-161
Mean fork length (mm)	103.7 ± 32.9	97.4 ± 18.3	104.6 ± 24.7	125.8 ± 17.0	133.8 ± 9.9
Range	68-165	68-123	75-143	98-150	119-155
Mean weight (g)	18.80 ± 16.88	13.65 ± 5.69	15.77 ± 10.76	25.54 ± 9.68	26.70 ± 7.24
Range	5.9 - 51.9	4.4 - 22.0	5.3 - 36.7	12.1 - 41.0	18.4 - 42.5
Mean volume stomach contents (ml)	0.49 ± 0.52	0.42 ± 0.38	0.33 ± 0.36	0.35 ± 0.25	0.51 ± 0.47
Range	<0.1 - 1.6	<0.1 - 1.5	<0.1 - 1.2	0 - 0.8	0.1 - 1.5
Condition coefficient	1.22	1.11	1.12	1.08	0.95

Table 10. Slimy sculpins collected in single application block*, McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	27 May	6 June	1 July	15 Aug.	26 Sept.
No. of fish sampled	9	11	10	10	10
Mean total length (mm)	67.8 ± 8.4	63.4 ± 11.0	63.4 ± 9.7	67.7 ± 7.0	71.5 ± 6.6
Range	52-78	50-85	54-85	55-75	61-81
Mean weight (g)	5.5 ± 1.5	3.32 ± 1.82	3.92 ± 1.80	4.85 ± 1.23	4.63 ± 1.49
Range	2.7 - 7.2	1.4 - 7.0	2.2 - 8.2	2.8 - 6.4	2.6 - 7.1
Mean volume Stomach contents (ml)	0.03 ± 0.02	0.10 ± 0.06	0.07 ± 0.03	0.04 ± 0.02	0.03 ± 0.02
Range	0 - <0.1	0 - 0.2	<0.1 - 0.1	0 - <0.1	0 - <0.1
Condition coefficient	1.74	1.20	1.47	1.54	1.23

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 11. Slimy sculpins collected in double application block*, Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	26 May	8 June	1 July	15 Aug.	26 Sept.
No. of fish sampled	4	10	10	9	8
Mean total length (mm)	67.8 ± 11.0	69.2 ± 13.8	66.0 ± 12.6	59.3 ± 10.2	74.4 ± 6.4
Range	57-80	43-85	44-82	42-70	65-85
Mean weight (g)	4.75 ± 2.15	5.25 ± 2.7	4.55 ± 1.91	3.59 ± 1.55	5.42 ± 1.45
Range	3.0 - 7.4	1.2 - 9.4	1.4 - 7.1	1.5 - 5.5	3.4 - 8.1
Mean volume Stomach contents (ml)	0.03 ± 0.02	0.23 ± 0.18	0.06 ± 0.03	0.06 ± 0.03	0.02 ± 0.02
Range	0 - <0.1	<0.1 - 0.5	0 - 0.1	0 - 0.1	0 - <0.1
Condition coefficient	1.46	1.45	1.50	1.63	1.29

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0705 hrs on 7 June 1980.

Table 12. Slimy sculpins collected in untreated control area, Young's Brook, York County, New Brunswick, 27 May to 27 September 1980

	27 May	7 June	2 July	15 Aug.	27 Sept.
No. of fish sampled	8	10	10	10	10
Mean total length (mm)	68.4 ± 6.9	70.7 ± 7.7	59.1 ± 5.3	61.2 ± 7.0	71.3 ± 5.4
Range	58-80	57-83	52-66	52-73	63-80
Mean Weight (g)	5.42 ± 1.65	4.22 ± 1.17	3.46 ± 0.97	3.14 ± 1.07	4.89 ± 1.05
Range	3.5 - 8.5	2.4 - 6.1	2.1 - 4.9	2.0 - 4.9	3.3 - 6.4
Mean volume stomach contents (ml)	0.05 ± 0.0	0.12 ± 0.08	0.05 ± 0.03	0.04 ± 0.02	0.06 ± 0.03
Range	<0.1 - <0.1	0 - 0.2	0 - 0.1	0 -<0.1	<0.05 - 0.1
Condition coefficient	1.66	1.18	1.64	1.33	1.34

APPENDIX VI

Stomach contents of fish from Young's Brook watershed, May to September 1980.

Table 1. Stomach contents of 1^+ Atlantic salmon collected in single application block*. McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present In				
Date	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.
No food present	10	11	0	11	0										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	30	33				13.1	11.2				2	3			
Other	90	89	10	22	10	64.7	25.9	9.9	4.4	3.0	2	3	1	1	3
Plecoptera nymphs		44	20	11	70		4.4	3.9	3.1	16.7		2	2	1	2
Megaloptera															
Sialidae					10					1.0					1
Trichoptera larvae	30	67		11	80	15.3	11.2		1.9	49.0	2	3		1	6
Diptera															
Athericidae		22	20	33	40		3.1	5.5	16.2	13.0		1	1	1	2
Chironomidae larvae		89	80	89	30		11.2	40.2	71.9	3.7		5	4	11	1
Chironomidae pupae	60	11				3.9	1.2				3	1			
Heleidae larvae		11				0.6						2			
Heleidae pupae			10					1.0					1		
Simuliidae larvae	10	78	20		20	0.1	24.6	5.0		5.6	1	15	2		1
Simuliidae pupae		22	20		20		0.8	1.4		3.8		1	1		1
Tipulidae	20	11	40	11	10	2.9	0.6	13.5	2.5	1.0	1	1	2	1	1
Other aquatic organisms															
Oligochaeta					10					0.5					1
Hydracarina					10					1.5					1
Terrestrial arthropods															
Homoptera		33	20		10		1.9	1.1		0.7		2	1		1
Lepidoptera larvae		22	10				1.9	3.0				2	1		
Hymenoptera					10					0.5					1
Diptera adults		22	40				1.2	15.5				1	1		
Number of fish in sample	10	9	10	9	10										

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 2. Stomach contents of 1^+ Atlantic salmon collected in double application block*
Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present In				
Date	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.
No food present	0	0	0	10	0										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	27	20				12.9	1.5				1	2			
Others	82	100	40	30	20	57.7	64.6	24.0	14.4	0.8	3	11	2	5	1
Plecoptera nymphs	27	100	30	20	60	6.5	18.0	4.0	11.7	16.2	2	8	1	2	2
Trichoptera larvae	27	60	40	20	80	6.1	6.2	14.0	2.2	50.9	1	3	1	4	3
Coleoptera adults			40					6.5					1		
Coleoptera larvae					10					0.2					1
Diptera															
Athericidae larvae		10	40	40			0.1	5.5	32.2			1	2	1	
Chironomidae larvae	36	60	70	60	30	2.5	2.1	10.5	6.7	0.7	2	2	4	6	1
Chironomidae pupae	9	10	50	20	10	0.5	0.1	7.0	1.7	0.4	1	1	2	2	4
Heleidae larvae			10	10				1.0	0.6				1	1	
Simuliidae larvae	45	20		20		9.0	0.2		1.1		4	1		3	
Simuliidae pupae	18		10			0.6		1.0			1		1		
Tipulidae larvae	18	60	20		30	2.3	5.3	9.0		4.0	1	4	3		2
Other aquatic organisms															
Oligochaeta				10	10				8.3	8.0				1	1
Gastropoda limpets			20					2.0					2		
Hydracarina		10	10				0.1	1.0				1	1		
Terrestrial arthropods															
Hemiptera	9	10			10	0.1	0.1			0.2	1	1			1
Homoptera		10	20	10	20		0.2	2.0	1.1	4.2		1	1	1	3
Trichoptera adults			10					2.0					1		
Lepidoptera larvae		30	10		10		1.2	2.0		0.5		2	1		1
Hymenoptera					10					1.5					1
Diptera adults	18	20	40	40	40	1.4	0.8	8.5	18.9	11.3	2	2	2	4	8
Araneida	18			10	10	0.5			1.1	0.1	2			1	2
Number of fish in sample	11	10	10	10	10										

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 3. Stomach contents of 1^+ Atlantic salmon collected in untreated control area. Young's Brook, York County, New Brunswick, 27 May to 27 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present in				
Date	27 May	7 June	2 July	15 Aug.	27 Sept.	27 May	7 June	2 July	15 Aug.	26 Sept.	27 May	7 June	2 July	15 Aug.	27 Sept.
No food present			0	25	0										
Aquatic insects	1^+ salmon not obtainable in stream	1^+ salmon not obtainable in stream				1^+ salmon not obtainable in stream	1^+ salmon not obtainable in stream				1^+ salmon not obtainable in stream	1^+ salmon not obtainable in stream			
Ephemeroptera nymphs															
Heptageniidae			25					0.8					1		
Others			75	12	22			4.2	0.8	7.2			2	1	1
Plecoptera nymphs			25	25	89			2.5	7.5	16.7			5	2	2
Trichoptera larvae			100	50	89			27.5	21.7	47.2			12	2	6
Trichoptera pupae					11					1.1					1
Coleoptera larvae				12					0.8					1	
Diptera															
Athericidae larvae			25	25	11			2.5	5.0	7.2			1	1	1
Chironomidae larvae			100	38	78			40.0	8.3	15.0			33	4	5
Chironomidae pupae			50	12				1.8	0.3				2	1	
Simuliidae larvae			75	25				14.5	9.2				9	2	
Simuliidae pupae			50	12				2.8	10.0				1	11	
Tipulidae larvae			25	12	33			0.5	16.7	4.4			1	1	2
Other aquatic organisms															
Hydracarina					11					1.1					1
Terrestrial arthropods															
Hemiptera				12					0.8					1	
Homoptera			25	12				0.5	0.8				2	1	
Lepidoptera larvae				12					6.7					1	
Diptera adults			25	25				1.2	10.8				1	2	
Unidentified pupae			25					1.2					1		
Number of fish in sample	0	0	4	8	9										

Table 4. Stomach contents of 2^+ Atlantic salmon collected in single application block*
McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present In				
Date	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.
No food present	10	0	0	11	20										
Aquatic insects															
Ephemeroptera nymphs															
Ephemerellidae		10					0.3					1			
Heptageniidae	30	50				10.9	6.2				2	2			
Other	90	100	30	33	20	45.0	18.8	14.6	6.0	4.9	3	9	2	2	2
Plecoptera nymphs	30	100	30	11		7.8	21.5	4.5	5.0		2	14	1	1	
Hemiptera															
Gerridae		10					0.4					1			
Trichoptera larvae	50	90		22	80	10.9	10.4		2.5	83.8	2	10		2	7
Trichoptera pupae		20					0.5					2			
Diptera															
Athericidae	40	70	40	11	10	4.4	3.1	4.8	3.8	6.2	2	2	2	1	1
Chironomidae larvae	80	100	80	78		5.0	3.1	27.3	32.2		2	6	8	7	
Chironomidae pupae		30	20				0.4	2.7				1	2		
Empididae larvae			20					1.3					1		
Heleidae larvae		20	10	22			0.2	0.1	0.6			2	1	1	
Simuliidae larvae	20	100	10	33	20	1.7	22.7	0.2	7.1	2.5	1	20	2	2	1
Simuliidae pupae		30	20				0.4	1.2				1	2		
Tipulidae larvae	30	60	20	11	10	13.2	2.0	2.3	2.5	1.2	1	2	2	1	1
Other aquatic organisms															
Oligochaeta		10					0.1					1			
Hydracarina		10	10		10		0.1	0.1		0.1		1	1		1
Decapoda			10					2.1					1		
Terrestrial arthropods															
Trichoptera adults				22					8.1					1	
Hemiptera		20	10	11			0.3	0.2	0.2			2	1	1	
Homoptera		100	50				4.5	5.6				4	1		
Lepidoptera larvae	10	50				1.1	1.6				1	2			
Hymenoptera			10	11				0.1	0.6				1	1	
Coleoptera adults		10	20	11			0.1	1.3	0.1			1	1	1	
Diptera adults		70	50	56	10		3.1	30.9	31.1	1.2		5	3	5	1
Araneida		20	10				0.2	0.7				1	1		
Number of fish in sample	10	10	10	9	10										

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 5. Stomach contents of 2^+ Atlantic salmon collected in double application block*
Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present In				
Date	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.
No food present	0	0	0	10	20										
Aquatic insects															
Ephemeroptera nymphs															
Ephemerellidae			10					6.0					1		
Heptageniidae	64	90				10.0	8.2				4	3			
Others	100	100	50		20	48.7	45.0	13.7		6.2	9	28	2		3
Plecoptera nymphs	45	100	20		40	7.3	26.0	2.1		13.4	2	26	1		3
Trichoptera larvae	73	90	40	10	80	10.0	9.3	4.7	4.4	44.9	3	12	2	1	3
Trichoptera pupae	9		10			0.5		0.5			1		4		
Coleoptera larvae					10					0.2					1
Diptera															
Athericidae larvae	27	50	20	10		3.5	2.9	6.5	2.2		2	2	1	1	
Chironomidae larvae	36	60	70	20	30	1.1	1.6	6.0	14.4	5.9	2	1	3	2	1
Chironomidae pupae			10					1.0					2		
Empididae larvae	18					0.3					1				
Heleidae larvae	9		10			0.4		0.2			1		1		
Simuliidae larvae	64			10		6.5			3.3		6			1	
Tipulidae larvae	36	90	60		30	2.4	4.6	15.3		2.9	2	4	2		1
Other aquatic organisms															
Oligochaeta	27					4.1					2				
Gastropoda limpets			10					0.5					1		
Hydracarina		10	10		10		0.1	0.4		0.1		2	1		1
Decapoda		20					0.7					1			
Unidentified fish			10					4.0					1		
Terrestrial arthropods															
Ephemeroptera adults					10					2.5					1
Plecoptera adults	9					1.4					2				
Hemiptera	9				10	0.6				0.1	1				2
Homoptera	18	10	30			0.7	0.5	2.7			1	1	2		
Trichoptera adults			40					15.2					1		
Lepidoptera larvae	36	30		20		1.7	1.0		16.7		2	3		1	
Hymenoptera															
Formicidae			10					0.1					1		
Formicidae (winged)			10					0.1					1		
Others					20					20.9					58
Coleoptera adults			20					1.8					1		
Diptera adults	18	20	50	60	30	0.9	0.2	17.0	58.9	2.9	2	1	11	4	2
Araneida			20					2.2					1		
Number of fish in sample	11	10	10	10	10										

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 6. Stomach contents of 2^+ Atlantic salmon collected in untreated control area, Young's Brook, York County, New Brunswick, 27 May to 27 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present in				
Date	27 May	7 June	2 July	15 Aug.	27 Sept.	27 May	7 June	2 July	15 Aug.	26 Sept.	27 May	7 June	2 July	15 Aug.	27 Sept.
No food present	0	0	0	10	0										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	78	80	20			24.3	6.4	1.0			5	2	1		
Others	78	100	50	50	50	17.8	9.7	8.7	16.1	3.7	3	2	5	2	1
Odonata-Anisoptera					10					2.7					1
Plecoptera nymphs	89	70	60	30	50	13.1	3.4	2.9	6.7	8.7	3	5	2	2	4
Trichoptera larvae	100	80	100	70	100	15.7	13.5	44.0	15.6	71.3	4	8	12	2	14
Trichoptera pupae		30					0.9					1			
Coleoptera adults			10					0.2					1		
Diptera															
Athericidae larvae	44	30	40	30	10	4.3	2.7	3.6	10.0	4.0	2	2	2	1	8
Chironomidae larvae	89	90	100	70	60	5.9	9.6	9.8	8.3	5.1	8	24	15	5	4
Chironomidae pupae		20	40	10			0.2	0.9	0.6			1	2	1	
Empididae larvae		10	20				0.2	0.2				1	1		
Heleidae larvae	11	10				0.6	0.1				2	1			
Simuliidae larvae	100	90	70	60	10	13.7	48.0	8.6	17.8	0.5	19	80	5	6	1
Simuliidae pupae	22	10	10	40		0.7	0.1	0.3	3.3		1	1	2	2	
Tipulidae larvae	22	80	40	20	30	1.6	5.1	3.5	5.0	1.5	1	2	3	1	2
Unidentified			10					0.2					2		
Other aquatic organisms															
Hydracarina	11		10			0.1		0.5			1		1		
Terrestrial arthropods															
Hemiptera	11				10	0.1				1.0	1				1
Homoptera			30		10			0.8		1.0			4		1
Trichoptera adults			10					1.0					2		
Lepidoptera larvae	11		30	10		0.3		1.5	0.6		1		1	1	
Hymenoptera	11		10	10		0.3		0.3	0.6		1		1	1	
Diptera adults	33	10	70	30	10	1.3	0.1	12.0	4.4	0.5	3	1	13	2	1
Araneida				10					11.1					1	
Collembola	11					0.2					2				
Number of fish in sample	9	10	10	10	10										

Table 7. Stomach contents of brook trout collected in single application block[*] McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present In				
Date	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.
No food present	0	0	0	0	20										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	80	80	30			5.1	10.4	4.9			2	79	1		
Other	90	100	30	40	40	36.2	14.3	11.0	2.8	25.0	10	77	2	2	2
Plecoptera nymphs	80	100	40	40		9.9	19.8	4.9	2.4		8	146	1	4	
Hemiptera															
Gerridae		30					0.3					3			
Trichoptera larvae	90	100	70		60	17.0	14.4	24.1		27.5	4	93	2		5
Trichoptera pupae		10			10		0.2			2.5		3			1
Coleoptera larvae				20					0.4					1	
Coleoptera adults		10	40				0.2	9.2				1	2		
Diptera															
Athericidae	80	90	20	20		8.7	2.0	1.9	0.4		2	7	1	1	
Chironomidae larvae	80	90	50	80		2.7	2.2	3.4	9.2		3	29	5	6	
Chironomidae pupae	10	70	20			0.5	0.8	0.2			1	4	2		
Empididae larvae		10					0.1					2			
Heleidae larvae	30	30	30	40		0.8	0.3	0.3	5.2		2	3	1	1	
Heleidae pupae					10					0.6					1
Simuliidae larvae	70	90				3.3	6.5				2	82			
Simuliidae pupae	30	30	60	60		0.4	0.3	1.6	2.4		2	2	2	3	
Tipulidae larvae	60	90				6.0	2.0				2	7			
unidentified larvae	10	10				0.2	0.1				1	1			
unidentified pupae		10					0.1					1			
Other aquatic organisms															
Nematoda			10	40				1.0	5.2				1	2	
Oligochaeta		20					0.2					1			
Hydracarina	40	30	50	20		0.4	0.3	3.4	5.0		7	2	2	2	
Decapoda		20					0.2					1			
Terrestrial arthropods															
Ephemeroptera adults		10					0.1					2			
Plecoptera adults	20	10				1.1	0.2				5	1			
Hemiptera		70					0.8					5			
Homoptera	10	100	20	60	10	0.4	5.4	1.1	3.0	2.5	9	33	3	2	2
Trichoptera adults			10					0.5					1		
Lepidoptera larvae	40	100	30	20		1.2	5.9	3.3	0.4		1	15	1	1	
Hymenoptera															
Formicidae		10					0.1					1			
Other	10	10	30	20	20	0.2	0.1	4.1	2.0	3.1	1	1	2	5	2
Coleoptera adults	10	50	20	20	20	0.5	0.8	4.0	0.4	4.4	1	2	4	1	1
Coleoptera larvae				20					0.6					2	
Diptera adults	70	100	60	80	60	5.3	10.9	20.3	60.0	34.4	65	57	4	10	5
Araneida	10	80	20	20		0.2	0.8	0.8	0.2		2	3	1	1	
Collembola		20					0.2					1			
Number of fish in samples	10	10	10	5	10										

[*]treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 8. Stomach contents of brook trout collected in double application block*
Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present In				
Date	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.
No food present	0	0	0		10										
Aquatic insects				brook trout not obtainable in stream					brook trout not obtainable in stream					brook trout not obtainable in stream	
Ephemeroptera nymphs															
Ephemerellidae	12	18				0.6	0.2				1	1			
Heptageniidae	100	82				5.1	4.7				3	6			
Others	100	100	100		20	33.4	34.7	5.0		5.6	2	153	2		1
Plecoptera	88	100				5.0	31.5				3	240			
Hemiptera															
Gerridae					10					11.1					5
Neuroptera															
Sisyridae	12					0.2					3				
Trichoptera larvae	100	100			40	25.0	13.2			31.1	14	72			3
Trichoptera pupae	50	9	100		10	2.0	0.1	4.0		2.8	2	3	2		1
Coleoptera adults	12	9	50		10	0.1	0.1	20.0		0.6	1	1	1		1
Diptera															
Athericidae larvae	50	27				1.5	0.4				2	2			
Chironomidae larvae	88	91	100			1.9	1.1	26.0			5	6	6		
Chironomidae pupae	38	36	50			0.6	0.5	17.5			2	3	5		
Empididae larvae			50					1.5					1		
Empididae pupae	12					0.1					1				
Heleidae larvae	75	9			10	1.6	0.1			0.6	4	1			1
Heleidae pupae	50					0.6					1				
Simuliidae larvae	62	55				1.6	0.6				3	4			
Simuliidae pupae		9					0.1					2			
Tipulidae larvae	100	91	50			7.2	6.9	1.0			3	24	1		
Other aquatic organisms															
Nematomorpha	12					0.1					1				
Oligochaeta	62				10	1.6				11.1	2				1
Hydracarina	12				10	0.1				2.2	3				1
Decapoda	38					2.1					2				
Unidentified fish						0.6					1				
Terrestrial arthropods															
Plecoptera adults		9					0.2					1			
Hemiptera	62	9	50		10	1.0	0.1	1.0		8.9	1	1	1		1
Homoptera	25	55				0.2	0.8				1	6			
Trichoptera adults					10					5.6					3
Lepidoptera larvae	88	82				3.6	1.3				2	4			
Hymenoptera	12	18			10	0.4	0.3			2.8	2	2			1
Coleoptera adults		27			20		0.5			15.0		2			2
Diptera adults	62	82	100		20	3.8	2.2	24.5		2.8	4	8	9		2
Araneida	25	36				0.6	0.4				1	1			
Number of fish in sample	8	11	2	0	10										

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 9. Stomach contents of brook trout collected in untreated control area. Young's Brook, York County, New Brunswick, 27 May to 27 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present in				
Date	27 May	7 June	2 July	15 Aug.	27 Sept.	27 May	7 June	2 July	15 Aug.	27 Sept.	27 May	7 June	2 July	15 Aug.	27 Sept.
No food present	0	0	0	10	0										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	70	58			10	7.1	5.2			0.2	2	1			2
Others	100	58	20	20	60	17.5	14.4	3.6	1.8	7.1	4	3	1	2	2
Plecoptera nymphs	100	75	60	50	40	12.5	5.4	6.9	8.9	2.5	5	4	2	2	2
Hemiptera															
Saldidae					10					0.1					1
Megaloptera															
Sialidae	10					0.1					1				
Trichoptera larvae	100	92	80	70	100	21.8	15.1	9.4	14.4	34.0	9	9	3	1	8
Trichoptera pupae				10					1.1					1	
Coleoptera adults		8	20					0.4	0.4			1	2		
Coleoptera larvae		8						0.1				1			
Diptera															
Athericidae larvae	80	83	10	10	10	4.3	8.5	2.0	0.9	2.3	2	2	1	1	3
Chironomidae larvae	100	83	90	60	40	9.1	8.6	14.9	3.9	1.2	7	17	13	3	2
Chironomidae pupae	70	25	50	10	20	3.1	0.8	4.8	0.1	0.4	5	2	5	1	1
Empididae larvae		8					0.1					1			
Heleidae larvae	30	42	30	10	10	0.6	1.6	0.9	0.1	0.1	3	3	2	1	1
Heleidae pupae			20		10			0.3		0.5			2		2
Simuliidae larvae	50	92	20	30	20	1.8	25.3	1.1	2.3	1.5	1	42	2	4	2
Simuliidae pupae		17	40		10		0.3	1.3		0.2		2	7		1
Tipulidae larvae	70	58		30	20	3.1	6.7		3.9	2.5	2	3		1	4
Unidentified pupae	20					0.2					1				
Other aquatic organisms															
Nematoda					10					0.1					1
Oligochaeta	10				20	0.5				3.6	1				1
Hydracarina	20	50	40	10	30	0.2	1.2	0.4	0.2	1.1	2	1	2	2	1
Decapoda			10					1.0					1		
Fish eggs		8					0.4					3			
Terrestrial arthropods															
Plecoptera adults	20	8		10	10	2.2	0.8		0.8	0.8	6	1		1	1
Hemiptera	10	8		30	40	0.1	0.4		2.7	1.5	1	1		1	2
Homoptera	20	25	90	20	80	0.3	1.2	9.7	2.2	6.2	1	1	5	2	2
Trichoptera adults	10		20		20	0.8		1.0		5.2	2		1		1
Lepidoptera larvae	30	8	20	60	40	2.1	0.2	0.6	24.1	3.0	2	1	2	3	4
Hymenoptera															
Formicidae					10					0.2					1
Other			30	30	40				5.6	3.9	5.5		2	1	3
Coleoptera adults		8	40	10	10		1.4	4.6	8.9	1.0		1	2	1	1
Diptera adults	70	42	80	60	90	7.6	1.8	32.5	19.4	18.2	11	3	26	12	5
Araneida		17	20	10	40		0.2	0.2	0.8	1.0		2	7	1	1
Collembola	60	8				4.0	0.1				26	4			
Number of fish in sample	10	12	10	10	10										

Table 10. Stomach contents of slimy sculpins collected in single application block*, McCallum Brook, York County, New Brunswick, 27 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present in				
Date	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.	27 May	6 June	1 July	15 Aug.	26 Sept.
No food present	22	9	0	30	10										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	11	18				5.7	3.0				1	2			
Others	78	82	50	40	30	72.1	58.3	18.0	36.4	16.1	2	4	1	1	1
Plecoptera nymphs		64	30		60		15.2	20.5		25.0		3	2		2
Trichoptera larvae		36	10		40		3.7	0.4		30.6		1	1		2
Coleoptera adults			30					9.1					1		
Coleoptera larvae	11					3.6					1				
Diptera															
Chironomidae larvae	22	73	90	60	30	2.9	6.5	41.8	53.9	4.7	5	6	9	23	1
Chironomidae pupae				10					0.4					1	
Empididae pupae			10					2.0					1		
Muscidae larvae			10					0.2					2		
Simuliidae larvae	33	27		20	10	10.7	1.8		9.3	2.8	2	3		3	4
Simuliidae pupae	11					1.4					1				
Tipulidae larvae	11	18	10		30	3.6	5.5	9.0		15.9	2	2	1		4
Other aquatic organisms															
Unidentified fish															
Fish eggs		9					6.0					4			
Terrestrial arthropods															
Lepidoptera larvae					10					5.0					1
Number of fish in sample	9	11	10	10	10										

*treated with 17.5 g AI/ha permethrin at 1850 hrs on 3 June 1980.

Table 11. Stomach contents of slimy sculpins collected in double application block* Young's Brook, York County, New Brunswick, 26 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present in				
Date	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.	26 May	8 June	2 July	15 Aug.	26 Sept.
No food present	0	0	10	11	38										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae		40					1.9					1			
Others	50	100	20	44	25	66.7	84.8	17.7	30.8	22.0	3	11	1	6	1
Plecoptera nymphs		50		11	13		1.2		6.2	9.0		3		1	2
Trichoptera larvae		20	10	22	38		1.7	4.4	0.6	36.0		4	1	1	1
Coleoptera adults			10					10.0					3		
Diptera															
Chironomidae larvae		60	70	78	25		2.0	30.7	33.6	21.0		2	9	2	4
Empididae larvae					13					10.0					1
Simuliidae larvae	25	10		33		33.3	0.1		28.8		1	1		8	
Tipulidae larvae		30	40		13		7.3	26.1		2.0		2	4		1
Other aquatic organisms															
Decapoda		10					1.0					1			
Unidentified fish			10					11.1					1		
Number of fish in sample	4	10	10	9	8										

*treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 12. Stomach contents of slimy sculpins collected in untreated control area. Young's Brook, York County, New Brunswick, 27 May to 26 September 1980

	Percent Occurrence					Mean Percent Contribution to Volume					Mean Number of Organisms Per Stomach Present in				
Date	27 May	7 June	2 July	15 Aug.	26 Sept.	27 May	7 June	2 July	15 Aug.	26 Sept.	27 May	7 June	2 July	15 Aug.	26 Sept.
No food present	0	10	10	20	0										
Aquatic insects															
Ephemeroptera nymphs															
Heptageniidae	38	20			10	26.9	1.8			1.5	2	1			1
Others	50	60	50	40	30	20.0	15.9	21.1	20.0	15.0	1	2	3	2	3
Plecoptera nymphs	25	40	20		40	5.6	1.6	2.8		4.0	1	2	2		2
Trichoptera larvae	25	50	20	20	70	10.2	14.7	0.8	13.8	35.5	1	1	1	2	3
Coleoptera adults			10					2.2					1		
Diptera															
Chironomidae larvae	62	80	90	50	80	16.1	30.8	48.0	2.8	38.0	10	14	22	2	13
Chironomidae pupae			20					3.1					2		
Empididae larvae	13					0.2					1				
Heleidae larvae	13					0.2					1				
Simuliidae larvae	38	70	20	50		5.6	33.4	3.0	50.0		1	41	2	7	
Simuliidae pupae				10					0.6					1	
Tipulidae larvae	25	30	40	10	30	15.0	1.9	13.3	0.6	6.0	4.	3	3	1	2
Other aquatic organisms															
Decapoda			10					5.6					1		
Terrestrial arthropods															
Lepidoptera larvae				10					12.2					1	
Diptera adults			10					0.1					1		
Number of fish in sample	8	10	10	10	10										

APPENDIX VII

Physical measurements and pH at caged fish and fish population study sites, Young's Brook watershed, 1980.

Physical measurements and pH at caged fish and fish population study sites, Young's Brook watershed, 1980

Site		1	2	3	4	5	6
Electrofishing dates		May 23	May 24	May 24	May 25	May 25	
		July 5	July 5	July 6	July 7	July 7	-
		Sept. 26	Sept. 25	Sept. 26	Sept. 29	Sept. 27	-
Electrofishing area (m^2)		273	200	292	275	242	
Mean width (m)		10.7	7.5	7.0	6.3	4.7	
Mean depth and one standard deviation (cm)							
Upstream net		41(13)	16(5)	16(5)	14(5)	15(5)	
Middle of site		22(7)	18(4)	27(6)	25(12)	27(4)	
Downstream net		25(8)	19(4)	25(11)	28(12)	14(6)	
Water temperature (°C) on treatment dates	3 June	11	11	10	11	11	11
	8 June	15	15	-	15	9	10
Water temperature range (May 30-June 18)		9-15	8-15	9-15	9-15	9-15	9-15
pH, mean and range (May-September)		6.8(6.7-7.0)	6.9(6.8-7.1)	6.8(6.5-7.0)	6.8(6.6-7.0)	6.8(6.7-7.1)	6.8(6.7-6.9)

APPENDIX VIII

Terrestrial invertebrates collected in knockdown buckets and on drop sheets set out in permethrin study areas, York County, New Brunswick, May to June 1980.

Table 1. Terrestrial invertebrate knockdown* from pin cherry blossom in double application block (site 2XB1)**, York County, New Brunswick, 30 May to 12 June 1980

	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 8	June 9	June 10	June 11	June 12
Arachnida: Acari		0.2												
Araneida						0.2								
Collembola		0.2		0.2	0.2						0.6	0.4		
Homoptera														
Cicadellidae							0.2							
Aphididae		0.2							0.2				0.2	
Other					0.4	0.2								
Coleoptera adults														
Carabidae	0.6				0.4									
Elateridae										0.2				
Curculionidae					0.2	0.2			0.2					
Other		0.2		0.2										
Lepidoptera larvae														
Tortricidae	1.4		0.2	0.2	0.4		0.6	0.2	0.2		0.4	0.4		0.2
Geometridae						0.2				0.2		0.2		
Diptera adults														
Culicidae				0.2										
Chironomidae	0.2													
Sciaridae	1.6	0.6	1.6	2.2	0.8	1.6	2.8	0.2	0.4	0.8	0.8	1.6	1.0	0.2
Other	0.2			0.4	0.2	0.4	0.8		0.8	0.8		0.8	0.2	0.6
Hymenoptera		0.2					0.2							0.2
Totals	4.0	1.6	1.8	3.4	2.6	2.8	4.6	0.4	1.8	2.0	1.8	3.4	1.4	1.2

*expressed as organisms per sampler.
**treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 2. Terrestrial invertebrate knockdown* from pin cherry blossom in double application block (site 2XB2)**, York County, New Brunswick, 30 May to 11 June 1980

	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 9	June 10	June 11
Arachnida: Araneida					0.2							0.2
Collembola										0.6	0.2	
Hemiptera						0.2						
Homoptera												
Aphididae						1.0			0.5		0.2	
Coleoptera adults												
Staphylinidae											0.2	
Curculionidae									0.5			
Other	0.2		0.2									
Trichoptera					0.2	0.2						
Lepidoptera larvae												
Tortricidae	0.2				0.2	0.5	0.2	0.2	1.0			
Geometridae						0.2						
Other					0.2							
Diptera adults												
Chironomidae		0.4										
Simuliidae											1.8	0.8
Tabanidae			0.2		0.2						0.2	
Sciaridae	2.2	0.6	1.0	1.4	1.6	1.0	0.8	0.6	4.0	2.0	3.6	2.0
Other	0.2				0.4	0.2	1.6	0.4		1.4	0.2	0.4
Hymenoptera	1.2		0.2	0.6	0.6	0.8	1.6	0.2	4.5		1.6	0.2
Totals	4.0	1.2	1.4	2.0	3.6	4.2	4.2	1.4	10.5	4.0	8.0	3.6

*expressed as organisms per sampler

**treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 3. Terrestrial invertebrate knockdown* from pin cherry blossom in untreated control block York County, New Brunswick, 30 May to 11 June 1980

	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 8	June 9	June 10	June 11
Arachnida: Araneida				0.2				0.2					
Homoptera								0.2					
Cicadellidae													
Aphididae								0.2					
Psyllidae	0.4	0.2	0.2	0.2			0.4						0.2
Other		0.4											
Coleoptera adults													
Staphylinidae	0.4	0.2											
Curculionidae	0.4												
Other		0.4				0.2							
Trichoptera adults	0.2												
Lepidoptera larvae													
Tortricidae	0.2			0.2									
Geometridae											0.2		
Other										0.2	0.4		
Diptera adults													
Sciaridae	1.6	0.8	0.2	0.6	1.0	0.6	0.2	0.2	0.4			0.6	0.4
Other	0.8		0.6							0.6	0.2	0.6	0.4
Unidentified larvae								0.2		2.0			
Hymenoptera adults													
Formicidae	0.4				0.2			0.4	0.2	0.4		0.2	
Other	1.6	0.4		0.2	0.8	0.2	0.2					0.2	0.2
Totals	6.0	2.4	1.0	1.4	2.0	1.0	0.8	1.4	0.6	3.2	0.8	1.6	1.2

***expressed as organisms per sampler.**

Table 4. Terrestrial invertebrate knockdown* from balsam fir foliage in double application block (site 2XB3)**, York County, New Brunswick, 30 May to 12 June 1980

	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 8	June 9	June 10	June 11	June 12
Arachnida: Acari		0.2				0.2			0.2					
Araneida										0.4	0.4	0.2		
Collembola	0.2					0.2						0.2	0.2	
Homoptera														
Cicadellidae										0.2				
Aphididae														0.2
Other			0.2			0.2								
Coleoptera adults														
Carabidae		0.2												
Other				0.2										
Lepidoptera larvae														
Tortricidae		0.2			1.4	0.6	0.6	0.2	0.6	1.2	0.6	1.0	0.2	1.0
Other					0.2									
Diptera adults														
Tipulidae					0.2									
Culicidae					0.6	0.4	0.6			0.2	0.2			
Cecidomyiidae	3.0													
Simuliidae				0.2										
Tabanidae					0.2				0.2					
Sciaridae	0.6	2.4	0.8	0.8		1.6	1.8	0.2	2.2	1.2	1.6	2.6	0.4	0.8
Chironomidae	0.4	0.2	0.6	0.2	1.4	0.4	0.8	0.8		0.4	0.2	0.2	0.2	0.4
Other	1.0		0.4		0.6									
Unidentified larvae													0.2	0.4
Hymenoptera														
Formicidae	0.2													
Other			0.6		0.2			0.2		0.2	0.2		0.2	
Totals	5.4	3.2	2.6	1.4	4.8	3.6	3.8	1.4	3.2	3.8	3.2	4.2	1.4	2.8

*expressed as organisms per sampler.
**treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 5. Terrestrial invertebrate knockdown* from balsam fir foliage in double application block (site 2XB4)**, York County, New Brunswick, 30 May to 12 June 1980

	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 8	June 9	June 10	June 11	June 12
Arachnida: Acari					0.4		0.2	0.6						
Araneida					0.4				0.2	0.4				
Collembola												1.8	12.4	0.2
Thysanoptera					0.2									
Hemiptera									0.2					
Homoptera														
Aphididae					0.2			0.4	0.2	0.8		0.4		
Other											0.8			
Lepidoptera larvae														
Tortricidae						0.4	0.2	0.2	1.0	2.0	0.6	0.2	0.2	0.4
Other					0.2									
Diptera														
Culicidae	1.0					1.2					0.4			0.2
Chironomidae				0.2	0.8		0.2	0.6	0.6	0.4		0.4	0.4	
Tabanidae											0.4			
Drosophilidae											0.2			
Sciaridae	3.2	1.4	0.6	2.0	3.6	2.4	1.6	3.6	4.6	0.6	0.4	2.8	0.4	0.4
Other	0.4	0.4	0.4	0.4	1.8	0.4			5.0	2.8	0.2	0.2		
Hymenoptera														
Formicidae		0.2	0.2											
Other	1.6	0.4		0.2	0.4	0.4	0.4		1.4				0.2	0.2
Totals	6.2	2.4	1.2	2.8	8.0	4.8	2.6	5.4	13.2	7.0	3.0	5.8	13.6	1.4

*expressed as organisms per sampler

**treated with 17.5 g AI/ha permethrin at 0618 to 0805 hrs on 3 June and again at 0600 to 0750 hrs on 7 June 1980.

Table 6. Terrestrial invertebrate knockdown* from balsam fir foliage in untreated control block, York County, New Brunswick, 30 May to 12 June 1980

	May 30	May 31	June 1	June 2	June 3	June 4	June 5	June 6	June 7	June 9	June 10	June 11	June 12
Arachnida: Acari			0.2										
Collembola									0.2				
Thysanoptera								0.2					
Homoptera													
Aphididae					0.2					0.2			
Coleoptera adults													
Elateridae		0.2											
Trichoptera				0.2				0.2					
Lepidoptera larvae													
Tortricidae	0.2			0.2					0.2		0.2		
Diptera adults													
Tipulidae											0.2		
Chironomidae	0.2												
Sciaridae	1.8	0.2	0.6	1.0		0.2	0.4		0.2	1.0	1.0	0.2	
Other		0.2	0.4	0.6			0.4			0.4	0.2		
Hymenoptera													
Formicidae			0.2								0.2		
Other	0.2		0.2							0.2			
Totals	2.4	0.6	1.6	2.0	0.2	0.2	0.8	0.4	0.6	1.8	1.6	0.4	0

*expressed as organisms per sampler.

Table 7. Terrestrial arthropods* collected from drop sheets placed under single balsam fir trees in single application block, York County, New Brunswick, 1980

	Application		
	1 day post-spray 4 June	2 day post-spray 5 June	Manual Treatment** 12 June
Arachnida: Phalangida	1		
Acari	1		3
Araneida	12		7
Collembola	4		3
Homoptera - Total adults	29	9	10
Cicadellidae	21	2	2
Aphididae	8	7	8
Coleoptera - Total adults	8	2	1
Carabidae	5	2	
Elateridae			1
Staphylinidae	1		
Other	2		
Unidentified larvae		1	
Trichoptera adults			4
Lepidoptera - Total larvae	38	36	22
Choristoneura fumiferana	35	36	21
Geometridae	3		1
Diptera - Total adults	225	34	227
Tipulidae			1
Bibionidae	1		
Culcidae	1		
Chironomidae	41	2	44
Sciaridae	47	7	68
Other	135	25	114
Unidentified larvae	1		
Hymenoptera - Total adults	17	5	7
Totals	336	87	285

*expressed as total number of organisms from two drop sheets.

**high-dosage emulsifiable concentrate permethrin solution applied with a hand sprayer to the sample trees.

Table 8. Terrestrial arthropods* collected from drop sheets placed under single balsam fir trees in double application block, York County, New Brunswick, 1980

	First Application			Second Application			
	10 hr post-spray 3 June	1 day post-spray 4 June	2 day post-spray 5 June	10 hr post-spray 7 June	1 day post-spray 8 June	2 day post-spray 9 June	Manual Treatment** 12 June
Arachnida: Acari		1					6
Araneida	1	3	3	2	2		19
Collembola		2	1	1		2	7
Homoptera - Total adults		12		3	4	8	13
Cicadellidae		8		2		1	
Aphididae		4		1	4	6	13
Other						1	
Coleoptera - Total adults		1	1		3		10
Carabidae					2		1
Elateridae		1	1		1		
Other							9
Unidentified larvae				1			
Trichoptera adults						1	
Lepidoptera - Total larvae	3	23	13	5	18	11	7
Choristoneura fumiferana	3	22	11	5	17	10	7
Geometridae		1	2		1		
Other						1	
Diptera - Total adults	14	27	12	35	30	26	101
Culicidae				2			
Chironomidae		1	1		1		4
Sciaridae	5	16	6	14	12	22	76
Other	9	10	5	19	17	4	21
Unidentified larvae						1	5
Hymenoptera - Total adults	3	1	1	4	5	1	6
Formicidae	1			1			
Other	2	1	1	3	5	1	6
Totals	21	70	31	51	62	50	173

*expressed as total number of organisms from two drop sheets

**high-dosage emulsifiable concentrate permethrin solution applied with a hand sprayer to the sample trees.

Table 9. Terrestrial arthropods* collected from drop sheets placed under single balsam fir trees in untreated control block, York County, New Brunswick, 1980

	3 June	4 June	5 June	7 June	8 June	9 June	Manual Treatment** 12 June
Arachnida: Acari							2
Araneida			1		2		7
Collembola					3		1
Homoptera - Total adults		1	1				8
Aphididae		1	1				6
Other							2
Coleoptera - Total adults			1	2			22
Curculionidae							1
Elateridae				1			1
Other			1	1			20
Trichoptera adults							
Lepidoptera - Total larvae		1	1				78
Choristoneura fumiferana		1	1				77
Geometridae							1
Diptera - Total adults	1	3	3	4	2	2	28
Chironomidae		1	1		1		
Sciaridae			1	3	1	1	10
Other	1	2	1	1		1	18
Hymenoptera - Total adults			1	2			4
Formicidae			1	1			
Other				1			4
Totals	1	5	8	8	7	2	151

*expressed as total number of organisms from two drop sheets

**high-dosage emulsifiable concentrate permethrin solution applied with a hand sprayer to the sample trees

APPENDIX IX

Fish collected from Young's Brook Watershed
and their stomach contents, May 1981.

Table 1. Fish collected from permethrin treated blocks and untreated control area approximately one year after treatment. Young's Brook, York County, New Brunswick, 20-21 May 1981

	Single application block			Double application block				Untreated control area		
	2+ salmon	brook trout	slimy sculpins	1+ salmon	2+ salmon	brook trout	slimy sculpins	2+ salmon	brook trout	slimy sculpins
No. of fish sampled	10	10	10	10	10	10	10	10	10	10
Mean total length (mm)	-	-	68.8 ± 8.1	-	-	-	66.7 ± 9.0	-	-	70.5 ± 5.1
Range	-	-	58.4	-	-	-	55-80	-	-	62-81
Mean fork length (mm)	93.8 ± 10.4	99.5 ± 30.5	-	61.0 ± 3.9	98.9 ± 5.6	118.8 ± 29.5	-	102.4 ± 11.3	91.6 ± 24.0	-
Range	79-119	56-142	-	56-68	92-110	64-160	-	87-125	58-112	-
Mean Weight (g)	10.8 ± 3.7	15.3 ± 11.5	6.3 ± 2.2	3.8 ± 0.6	13.0 ± 2.4	25.8 ± 17.5	5.2 ± 1.6	14.0 ± 4.6	11.4 ± 6.2	6.2 ± 1.6
Range	7.1 - 20.6	3.1 - 36.2	3.8 - 11.3	2.5 - 4.4	10.4 - 16.7	2.9 - 60.2	2.7 - 7.6	8.9 - 22.3	3.0 - 20.5	3.8 - 9.4
Mean volume of stomach contents (ml)	0.15 ± 0.09	0.60 ± 0.51	0.05 ± 0.01	0.11 ± 0.05	0.36 ± 0.27	1.66 ± 1.36	0.07 ± 0.04	0.34 ± 0.26	0.39 ± 0.24	0.08 ± 0.03
Range	0.0 - 0.3	0.1 - 1.6	0.0 - 0.15	0.1 - 0.2	0.1 - 0.9	0.3 - 4.6	0.0 - 0.1	0.1 - 0.7	0.01 - 0.8	0.1 - 0.1
Condition coefficient	1.29 ± 0.13	1.31 ± 0.20	1.89 ± 0.13	1.66 ± 0.25	1.33 ± 0.10	1.28 ± 0.17	1.74 ± 0.25	1.26 ± 0.12	1.40 ± 0.28	1.72 ± 0.16
Mean volume of food organisms consumed per mm of fish x 10^3	1.60	6.03	0.73	1.80	3.64	13.97	1.05	3.32	4.26	1.13

Table 2. Stomach contents of fish collected in untreated control stream Young's Brook, York County, New Brunswick, 20 May 1981

350 days post-application	Percent occurrence			Mean percent contribution to volume			Mean number of organisms per stomach present in		
	2+ salmon	brook trout	slimy sculpins	2+ salmon	brook trout	slimy sculpins	2+ salmon	brook trout	slimy sculpins
No food present	0	0	0						
Aquatic insects									
Ephemeroptera nymphs									
Heptageniidae	80	30	20	20.8	0.4	13.5	3	2	1
Other	100	80	70	40.5	16.5	35.8	8	7	3
Plecoptera nymphs	70	80	40	5.2	3.5	4.5	2	7	1
Trichoptera larvae	80	100	40	19.2	25.1	21.5	4	9	3
Coleoptera adults	10	-	-	0.3	-	-	3	-	-
Diptera									
Athericidae	30	20	10	2.8	3.0	0.1	1	4	1
Chironomidae larvae	10	70	10	0.1	1.5	10.0	1	4	3
pupae	-	80	-	-	1.8	-	-	10	-
Empididae larvae	10	50	-	0.2	1.6	-	1	2	-
Heleidae larvae	-	50	-	-	0.7	-	-	1	-
Simuliidae larvae	80	80	50	9.6	12.1	6.0	8	9	3
pupae	-	20	-	-	0.2	-	-	1	-
Tipulidae larvae	40	60	20	0.6	2.4	6.5	2	3	3
Other aquatic organisms									
Nematoda	10	10	-	0.1	0.1	-	1	1	-
Hydracarina	-	10	-	-	0.1	-	-	1	-
Oligochaeta	-	20	10	-	0.2	0.1	-	2	1
Terrestrial arthropods									
Plecoptera adults	-	30	-	-	1.8	-	-	1	-
Lepidoptera larvae	-	30	-	-	26.6	-	-	6	-
Diptera adults	-	20	10	-	1.3	2.0	-	9	1
Chilopoda	-	10	-	-	0.1	-	-	1	-
Araneida	10	10	-	0.1	0.1	-	1	1	-

Table 3. Stomach contents of fish collected in single application block* McCallum Brook, York County, New Brunswick, 20 May 1981

350 days post-application	Percent occurrence			Mean percent contribution to volume			Mean number of organisms per stomach present in		
	2+ salmon	brook trout	slimy sculpins	2+ salmon	brook trout	slimy sculpins	2+ salmon	brook trout	slimy sculpins
No food present	0	0	40						
Aquatic insects									
Ephemerellidae nymphs									
Heptageniidae	80	20	-	21.2	0.6	-	2	1	-
Other	70	90	30	29.4	46.8	42.8	4	13	3
Plecoptera nymphs	10	70	10	0.6	3.1	5.8	2	2	1
Trichoptera larvae	20	90	-	3.3	19.5	-	1	5	-
Coleoptera adults	10	-	-	11.1	-	-	1	-	-
Diptera									
Athericidae larvae	10	10	-	5.6	0.5	-	2	1	-
Chironomidae larvae	70	70	30	5.6	1.4	15.2	5	4	2
pupae	10	50	-	0.1	0.9	-	1	3	-
Heleidae larvae	-	30	-	-	1.4	-	-	4	-
Simuliidae larvae	40	60	30	9.0	6.5	7.0	16	3	1
pupae	10	20	-	0.2	0.4	-	1	2	-
Tipulidae larvae	40	40	30	14.4	4.1	27.5	5	4	4
Unidentified pupae	10	-	-	3.3	-	-	1	-	-
Other aquatic organisms									
Nematoda	20	10	-	0.3	0.1	-	1	1	-
Hydracarina	-	20	-	-	0.2	-	-	1	-
Oligochaeta	-	10	20	-	0.1	1.7	-	1	2
Terrestrial arthropods									
Ephemeroptera adults	-	10	-	-	1.1	-	-	1	-
Plecoptera adults	-	30	-	-	0.8	-	-	2	-
Trichoptera adults	-	10	-	-	0.5	-	-	1	-
Homoptera	-	30	-	-	0.7	-	-	1	-
Lepidoptera larvae	-	50	-	-	13.5	-	-	5	-
Diptera adults	10	80	-	0.2	2.5	-	1	3	-
Araneida	-	30	-	-	0.5	-	-	1	-

* treated with 17.5 g AI/ha permethrin at 1850 h on 3 June 1980.

Table 4. Stomach contents of fish collected in double application block* Young's Brook, York County, New Brunswick, 20 May 1981

	Percent occurrence				Mean Percent contribution to volume				Mean number of organisms per stomach present in			
350 days post-application	1+ salmon	2+ salmon	brook trout	slimy sculpins	1+ salmon	2+ salmon	brook trout	slimy sculpins	1+ salmon	2+ salmon	brook trout	slimy sculpins
No food present	0	0	0	20								
Aquatic Insects												
Ephemeroptera nymphs												
Heptageniidae	80	70	50	20	37.2	28.5	1.4	6.9	4	16	2	2
Others	90	100	100	70	45.2	52.3	61.1	62.4	7	16	91	4
Plecoptera nymphs	10	20	50	-	0.5	6.6	0.9	-	1	1	2	-
Hemiptera												
Veliidae	-	-	10	-	-	-	0.2	-	-	-	1	-
Megaloptera												
Sialidae	-	-	10	-	-	-	0.2	-	-	-	1	-
Trichoptera larvae	10	90	90	20	0.2	8.6	4.6	5.0	1	3	3	1
Coleoptera adults	-	-	10	-	-	-	0.1	-	-	-	1	-
Coleoptera larvae	-	-	10	-	-	-	0.1	-	-	-	1	-
Diptera												
Athericidae larvae	-	-	30	-	-	-	0.7	-	-	-	1	-
Chironomidae larvae	40	60	100	40	1.0	0.9	1.2	14.0	2	2	2	1
pupae	-	-	70	-	-	-	1.6	-	-	-	4	-
Empididae larvae	10	-	10	-	0.2	-	0.1	-	1	-	1	-
Heleidae larvae	-	-	30	-	-	-	0.4	-	-	-	2	-
Simuliidae larvae	60	60	40	-	2.4	2.3	1.8	-	2	5	7	-
pupae	10	-	10	-	0.4	-	0.1	-	1	-	2	-
Tipulidae larvae	60	50	30	30	6.9	0.8	3.9	11.8	1	2	2	4
Other Aquatic organisms												
Nematoda	-	-	10	-	-	-	0.5	-	-	-	11	-
Hydracarina	-	-	30	-	-	-	0.3	-	-	-	1	-
Terrestrial arthropods												
Ephemeroptera adults	10	-	30	-	3.0	-	2.3	-	1	-	19	-
Plecoptera adults	-	-	50	-	-	-	4.1	-	-	-	7	-
Trichoptera adults	-	-	10	-	-	-	6.0	-	-	-	14	-
Homoptera	-	-	10	-	-	-	0.5	-	-	-	1	-
Lepidoptera larvae	10	-	10	-	3.0	-	0.2	-	1	-	3	-
Hymenoptera adults	-	-	30	-	-	-	0.3	-	-	-	1	-
Coleoptera adults	-	-	20	-	-	-	2.2	-	-	-	1	-
Diptera adults	-	-	80	-	-	-	4.2	-	-	-	34	-
Unidentified insect	-	-	10	-	-	-	0.1	-	-	-	1	-
Araneida	-	-	40	-	-	-	0.7	-	-	-	2	-
Collembola	-	-	10	-	-	-	0.1	-	-	-	1	-

* treated with 17.5 g AI/ha permethrin at 0618 to 0805 h on 3 June and again at 0600 to 0750 h on 7 June 1980.